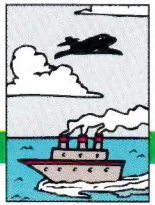
Who invented the rudder?



BY AIR AND BY SEA

1. The Chinese
2. The Romans
3. The Greeks

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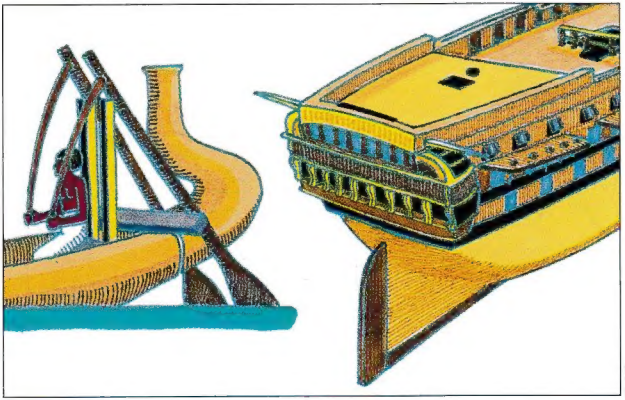
Rudder

The fixed stern rudder was invented in China in the 1st century.

1 The Chinese invented the rudder.



Ill. J. Doug

The rudder is steered by the tiller. Its invention meant larger ships could be built to carry more cargo

Chinese Tradition

The Chinese used boats with rudders long before the Europeans adopted the idea. European boats with rudders were first reported in the 12th century. Little by little, the ruddered boats replaced the old giant parallel paddles at the back of the boat, that had to be steered by hand.

Stern Post Rudders

These rudders were so named because they pivoted on metal pintles and gudgeons that were firmly fixed to the stern post– part of the rear of the ship's hull. Stern-post rudders were steered by the action of the tiller.

This new invention meant that much bigger and more maneuverable ships could be built. In about 1300 A.D., Venetian merchants, who were great seamen, adopted this new system they'd seen used by Basque pirates.

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D3 054 03-04

What do air traffic controllers do?

BY AIR AND BY SEA

1. Control airplane speeds on take off
2. Pass weather information to pilots
3. Guide air traffic in and out of airports

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Air Traffic Controllers

In major airports, air traffic controllers handle over 3,000 take-offs and landings each day–about 190 flights per hour!

3 **Air traffic controllers guide air traffic in and out of airports.**

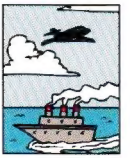

Photo Malgiave / Explorer

From the top of the control tower 260 ft (80 m) above the runway at Charles de Gaulle airport in Paris, air traffic controllers do their work.

The Control Tower

An airport's nerve center is in the control tower. There, in the visual control room, air traffic controllers guide planes taking off, taxiing on runways, and making their final approaches for landing. Assistants run computers that estimate when planes will be arriving and programs flight departure times so that runway space can be allocated.

Lower down in the tower, controllers watch their radar screens, determining the positions of all approaching aircraft. If the wind has changed the landing direction or if too many aircraft arrive at the same time, controllers direct them into a holding pattern–stacking them up over the airport guided by a radio beacon. It's up to the air traffic controllers to make sure there's ample time between landings so everyone lands safely.

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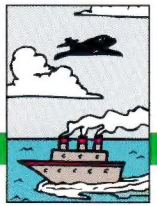
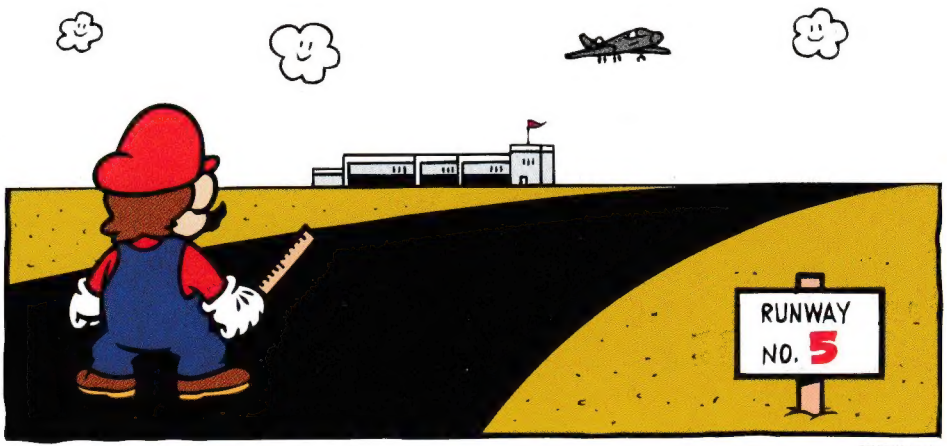
How long are the longest airport runways?



BY AIR AND BY SEA

1. About 6,000 feet (about 1,850 meters)
2. About 14,500 feet (about 4,500 meters)
3. About 24,500 feet (about 7,550 meters)



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Airports

The great airports of the world have runways that are 13,000 or 14,500 ft (4,000 or 4,500 m) long. This distance allows big aircraft, carrying a lot of fuel, to have enough room to get up to take-off speed.

2 The longest airport runways are about 14,500 ft (4,500 m) long.

Photo Malglave / Explorer

Landing at London Airport. Runways are lit up at night.

Runway Length

A runway of 6,000 ft (1,850 m) may be long enough for short-haul aircraft to take off, but bigger aircraft need more room. For example, in hot climates or at high-altitude airports, greater distances are needed to get up the power for takeoff. Take-off speed is determined by air density which is affected by heat and high altitude.

Landing

The same applies for landing. The heavier the aircraft, the more important braking distance becomes. In addition, if the runway is wet and slippery, even longer distances are needed. Planes also need a clear zone at each end of the runway, to allow space to rise and descend.

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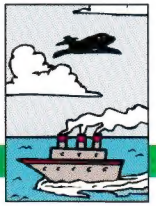
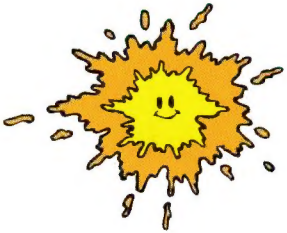
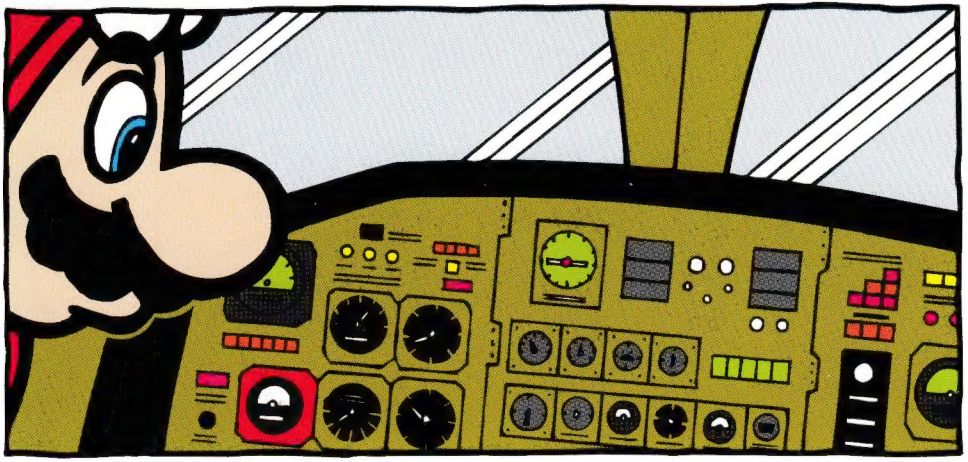
How many instruments are there in the cockpit of an airplane?



BY AIR AND BY SEA



1. A maximum of 12
2. 25
3. Up to 150



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Cockpit

In an airplane, pilots have up to 150 instruments in front of them.

3 There are up to 150 instruments in the cockpit of an airplane.

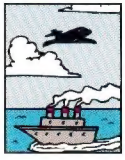

Photo Thibaut / Explorer

In the cockpit, some instruments are read by figures, others by dials.

"Good afternoon, ladies and gentlemen, this is your Captain speaking ..."

From time to time, the pilot runs his eyes over the panel of instruments. Fundamental ones, such as the anemometer (records speed), altimeter (records height), false horizon (shows the plane's angle in relation to Earth's horizon), and heading (shows route direction), are in front of each pilot. So is the automatic pilot, which can be pre-set to maintain and correct the plane's flight heading. Other dials show the pilot the oil pressure and fuel levels.

Duplicate Instruments

If a pilot were ever to feel ill, the co-pilot would take over immediately. And it's nice to know that alarms light up in the cockpit the minute there's a problem with any instrument or control.

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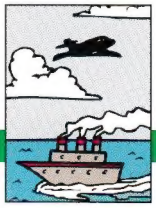
D3 054 03-08

How fast must a plane go for takeoff?



BY AIR AND BY SEA

1. About 310 miles (500 km) per hour
2. About 180 miles (290 km) per hour
3. About 105 miles (170 km) per hour

©1995 Nintendo

Takeoff

As a plane taxis down the runway, the pilot accelerates the craft. When the speedometer reads about 180 miles (290 km) per hour, air pressure on the wings lifts the plane off the ground.

2 **To achieve takeoff, a plane must accelerate to about 180 miles (290 km) per hour.**

Photo © E. de Malglaive / Explorer

A DC 10 gathers speed as it roars down the runway, then takes off into the wild blue yonder.

Speed May Vary

The actual speed needed for takeoff varies, depending on weather conditions at the airport. For example, with a favorable 19-mile- (30-km-) per-hour wind, planes might achieve lift-off with a speed of 174 miles (280 km) per hour. Similarly, with unfavorable winds, planes might need to be going faster.

V1 and V2

The point at which a pilot decides the plane has reached proper speed for takeoff is called V1. Until V1, the pilot could abort takeoff, apply the brakes, reverse the plane's forward thrust, and return to the terminal. After V1, the pilot is at V2 during which the controls are pulled back to raise the plane's nose about 12 degrees. At that point, the plane becomes airborne and reaches the altitude assigned to the pilot by an air traffic controller working at the airport.

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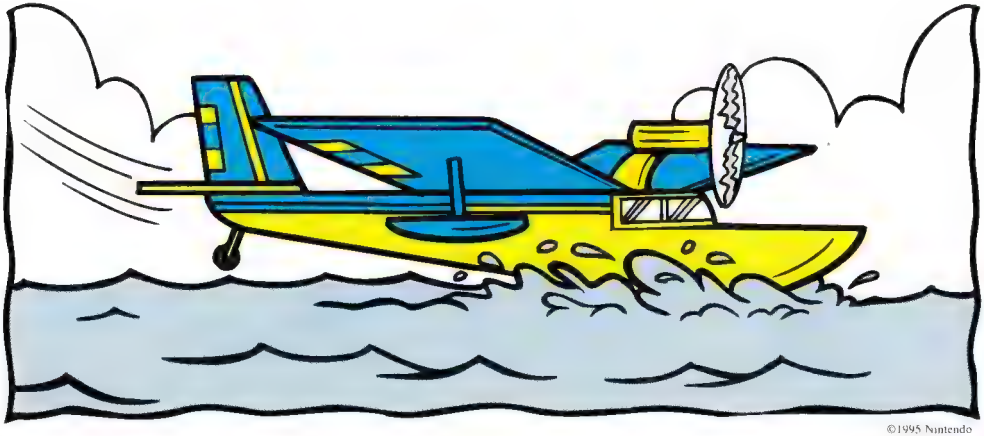
D2 491 04-06

What plane takes off and lands on water?

BY AIR AND BY SEA

1. 747 jet
2. Hovercraft
3. Seaplane



©1995 Nintendo

Seaplane

Thanks to the pontoons attached to its frame, a seaplane can take off and land on water. The pontoons allow the plane to float on the water and to skim across it for take-off.

3 A seaplane takes off and lands on water.

Photo © M. Moustard/Explorer

As the seaplane increases speed for take-off, it skims over the surface of the water just like a water-skier!

There are three kinds of seaplane: floatplanes, flying boats, and amphibians. The first two take off and land on water only. But thanks to retractable wheels, amphibians can take off and set down on both water and dry land.

Pontoon Problems

Designing pontoons that allowed planes not only to float in water but to skim across it at high speeds necessary for take-off posed problems. Pontoons are heavier than wheels and cause more drag because they can't be flipped up into the craft. Lightweight retractable skis called hydroskis solved the problem. At low speed, they stabilize the aircraft; at high speed they allow it to lightly skim the water's surface.

Shapely Structure

The underside of a seaplane's hull is V-shaped to cut through the water. The hull must also be solid enough to withstand bumping waves as it speeds toward take-off or lands in the water.

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D2 491 06-05

How much oil can an oil tanker carry on board?

BY AIR AND BY SEA

1. 6,000 tons
2. 66,000 tons
3. 660,000 tons

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Tanker

Metal tanks were once put on cargo ships to transport oil. In 1886 a German steamboat was the first vessel to store oil directly against the hull. Since then, bigger ships have been built to transport only oil.

3 **The biggest oil tanker can carry about 660,000 tons.**

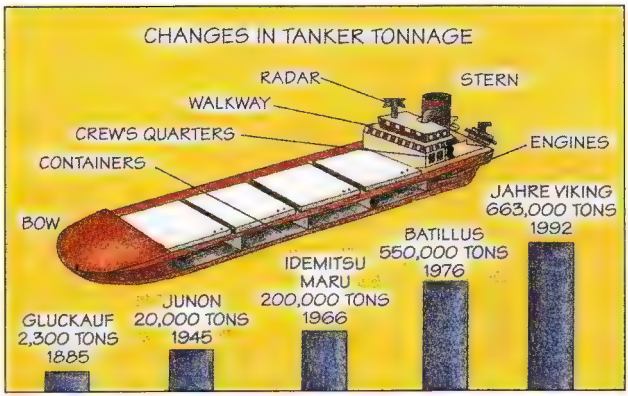

Illustration by Mimi Perrotta

Oil is loaded and unloaded from a pier or offshore from buoys that extend out from huge storage tanks.

In the 1960s and 70s, supertankers were developed to carry more oil. The deck of a supertanker is empty: engines and crew of 25-40 are housed at the rear of the vessel. Below deck, bulkheads or walls run the length and width of the ship to create up to 25 compartments. The bulkheads strengthen the ship's hull and keep the liquid cargo from sloshing about.

Tanks a Lot!

The largest tanker ever built, Jahre Viking, is 1,504 feet (458 m) long and 225 feet (69 m) wide. When full of oil, the hull goes 80 feet (24 m) into the water. Pumps siphon the oil from the compartments one after another. To keep the ship balanced, each compartment is filled with sea water as it becomes empty.

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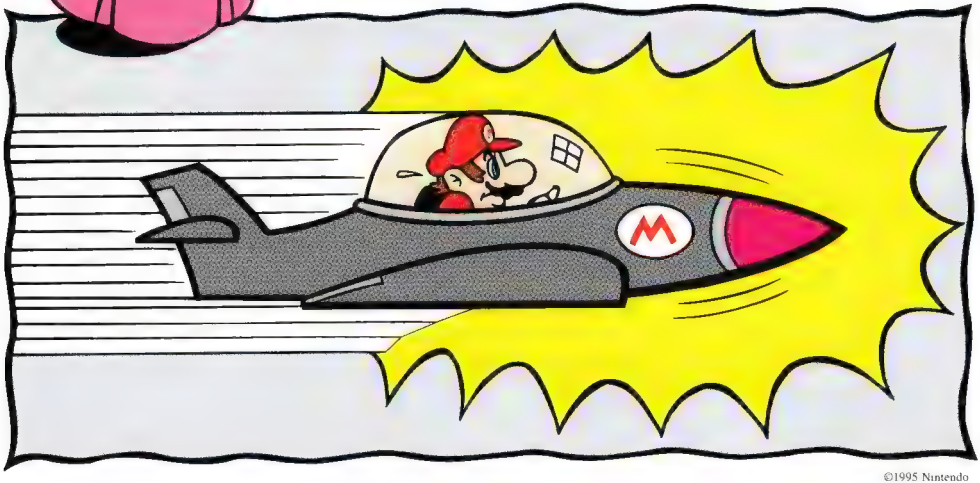
D3 491 07-20

At what speed does a plane break the sound barrier?

BY AIR AND BY SEA

1. 496 miles (800 km) per hour
2. 760 miles (1,225 km) per hour
3. 1,633 miles (2,500 km) per hour



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Speed of Sound

An aircraft breaks the sound barrier when it passes the speed of 760 miles (1,225 km) per hour or slows down again below that speed. Each time the barrier is broken, there is a loud cracking sound, called a sonic boom.

An object moving through air makes waves or vibrations, similar to those made in water by a boat. Because of a plane's size, shape, and engine noise, it's a source of strong waves. The waves increase until they reach the speed of sound, approximately 760 miles (1,225 km) per hour at low altitudes.

2 **A plane breaks the speed of sound at 760 miles (1,225 km) per hour.**

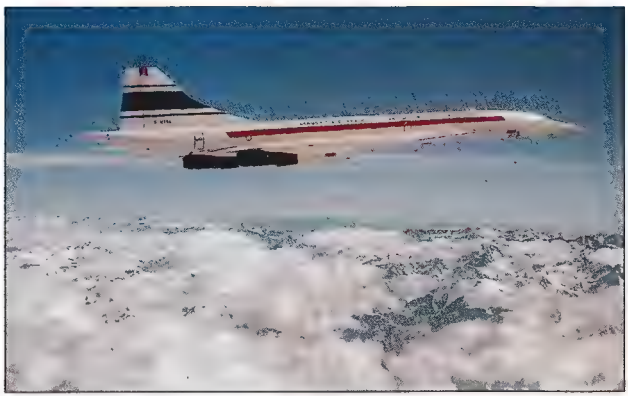

Photo © Deau / Explorer

When a plane breaks the sound barrier, compressed energy in the shock wave could, at low altitude, split an eardrum or crumble an old wall!

Bang-Bang!

As a plane passes the speed of sound, it produces shock waves in the air around the leading edge of the craft. This creates a sharp compression of air followed by a quick decompression and results in a BANG...BANG! The sound barrier has been broken and the vibrations could shatter windows in houses below. That's why planes aren't allowed to fly at supersonic speed except over the ocean and sparsely populated areas.

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D3 054 08-17

Who designed the first helicopter?

BY AIR AND BY SEA

1. Leonardo da Vinci
2. Louis Heliman
3. Rudolph Copter

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Helicopter

In 1483, Italian artist and scientist Leonardo da Vinci sketched a design for a helicopter. But the first practical "chopper" wasn't flown until 1939.

1 Leonardo da Vinci designed the first helicopter.

Photo © D.R

Thanks to its angled blades, a helicopter can hover overhead.

Leonardo da Vinci (1452-1519) is best known for paintings like *The Last Supper* (1495) and the *Mona Lisa* (1514). But this great painter was also a scientist who was fascinated by movement. His helicopter sketch shows a screwlike wing made of starched linen. Of course, it never got off the ground, but eventually a real helicopter did.

Keeping It Up

A helicopter's blades provide lift, allowing the craft to leave the ground and remain aloft. The motor supplies speed for forward motion and the pilot controls the blades' tilt (pitch) to move the ship backward, sideways, or to hover over the ground. In 1939, the first workable helicopter was built and flown in the U.S. by Igor I. Sikorsky. Versions of his designs are still used today. If one hovers overhead, you'll hear the sound that earned it the nickname "chopper."

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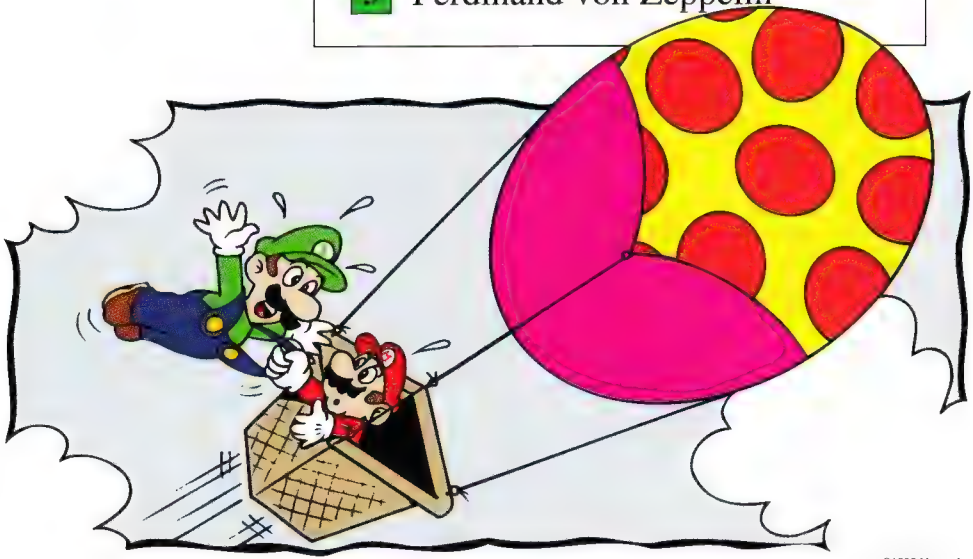
D3 054 09-06

Who launched the first hot air balloon?

BY AIR AND BY SEA

1. Benjamin Franklin
2. Joseph and Jacques Montgolfier
3. Ferdinand von Zeppelin



©1995 Nintendo

Hot Air Balloons

The Montgolfier brothers, Jacques (1745-99) and Joseph (1740-1810), invented the hot air balloon. They used large bags of hot gas, produced by burning wool and moist straw.

2 The Montgolfier brothers, Joseph and Jacques, launched the first hot air balloon.

Photo © R. Nowitz / Explorer

Warm air rises, so heated air released into a balloon lifts it. When air in the balloon cools, the craft descends.

The Montgolfier brothers, 18th century French inventors, were among the earliest aviation pioneers. Their experiments with hot air balloons are the first recorded instances of manned flight. After two launches without passengers, the Montgolfiers selected three unusual passengers—a sheep, a duck, and a rooster—for their third balloon launch, in September 1783. When the animals returned safely to Earth, the brothers knew it was possible to breathe in flight.

First Human Flight

On November 21, 1783, a Montgolfier balloon carried two Frenchmen, the first humans to experience free flight. During their 25-minute ride above Paris, the men had to shovel straw on the fire to keep the balloon aloft, and flames threatened to destroy the canvas balloon lined with paper. But they managed to land safely about 5 miles (8 km) away from their point of takeoff!

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D3 054 11-18

What is a dirigible?

BY AIR AND BY SEA

1. A submarine
2. A solar-powered train
3. An airship

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Dirigible

A dirigible is a lighter-than-air, self-moving aircraft whose ability to float is provided by gasbags containing hydrogen or helium.

3 A dirigible is an airship.

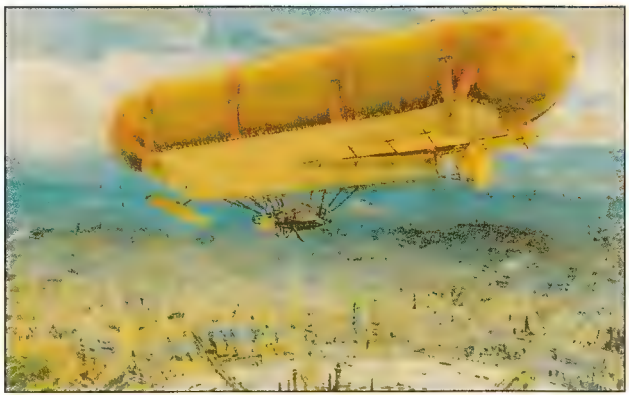

Photo © Archives Explorer

Rising warm air inside the balloon-skin envelope helps the ship rise vertically: the motor and propeller give it power to move horizontally.

In 1852, Henri Giffard designed and flew the first successful dirigible over Paris. Later, Count Ferdinand von Zeppelin of Germany built dirigibles that became known as "Zeppelins." They were considered an exciting, modern means of travel until one of Count Zeppelin's luxury passenger airships, the Hindenberg, made an ill-fated voyage to the U.S. in 1937. The hydrogen-filled dirigible burst into flames and crashed in New Jersey, killing all those on board.

Airship Uses

During World War I, dirigibles played an important role in intelligence gathering missions and for night bombing raids. But with the progress of air travel and the perfecting of anti-aircraft weapons, dirigibles became defenseless. The big airships were later used for the exploration of Arctic territories. Though they look similar to the advertising blimps that often float above sports stadiums and parades, dirigibles have a rigid outer shell. Blimps have a non-rigid shell.

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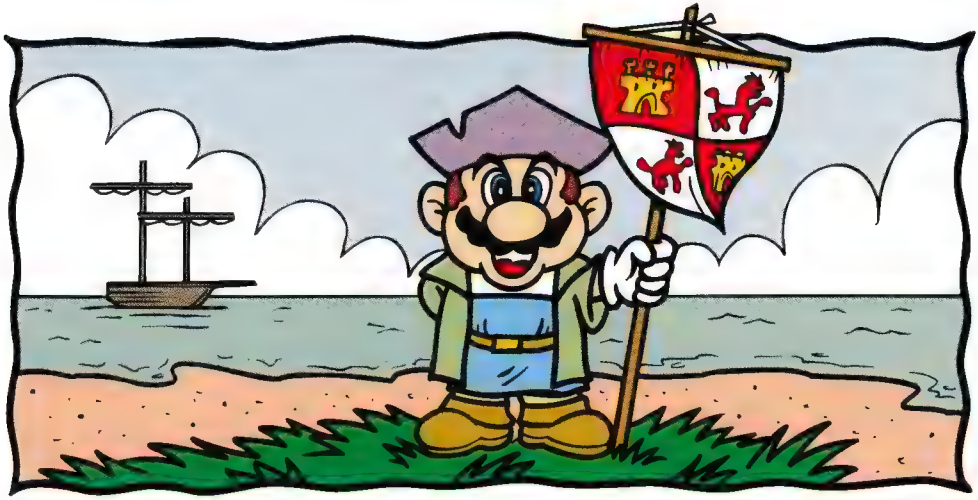
D3 054 12-18

On which continent did Columbus think he had landed in 1492?

BY AIR AND BY SEA

1. Asia
2. North America
3. Antarctica



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Christopher Columbus

On August 3, 1492, Columbus sailed west from Spain in search of a route to India, China, and Japan.

1 Columbus believed he had reached Asia.

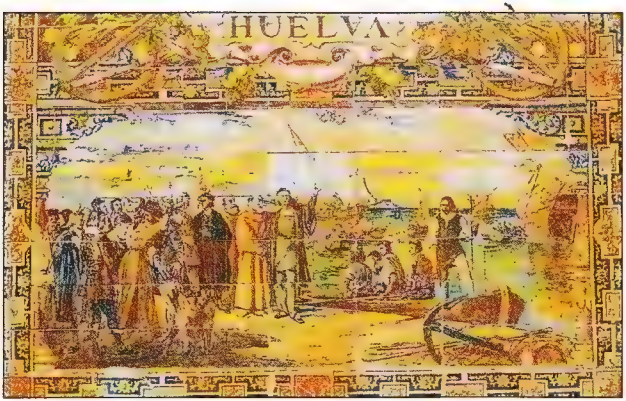

Photo © J. P. Courcau / Explorer

Columbus sailed from the province of Huelva in southwest Spain, marking the start of European exploration of the New World.

On October 12, he landed on an island in what is now the West Indies, never knowing that nearby were two huge continents—North and South America. Believing he and his crew had landed in the East Indies off the coast of China or Japan, Columbus called the people on the island "Indians." He also found other islands, those known today as Cuba, the Dominican Republic, and Haiti. Then, with some of the "Indians" aboard, Columbus returned to Spain.

A Triumphant Return

Spain's Queen Isabella held a great reception to welcome Columbus home. He gave her gold trinkets from the New World, and she gave him two titles: Admiral of the Ocean Sea and Viceroy of the Indies. She also paid for more voyages, which Columbus made without ever finding a "shortcut" to Asia. He did, however, finally reach the mainland of South America.

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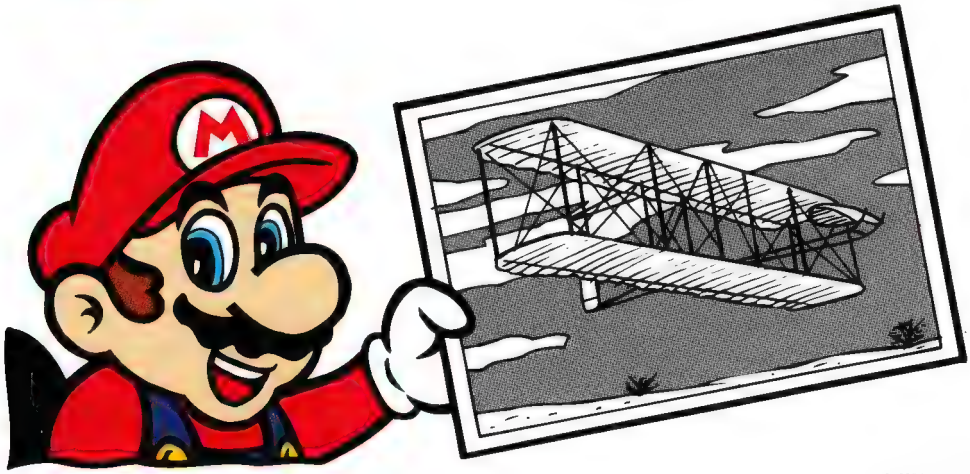
D3 054 14-02

Who designed and flew the first power-driven airplane?

BY AIR AND BY SEA

1. Charles Lindbergh
2. Louis Boeing
3. Orville and Wilbur Wright



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The Wright Brothers

As young boys, Wilbur (1867-1912) and Orville (1871-1948) Wright sold homemade mechanical toys. In their 20s, the young men made bikes, and in their 30s, they built and flew their own airplane.

3 Orville and Wilbur Wright were the first to design and fly a power-driven airplane.

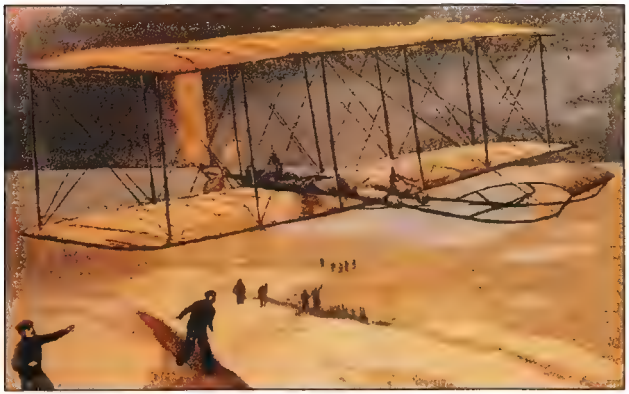

Photo © M. Evans / Explorer Archives

The Wrights first flight was witnessed by a boy and four men, one of whom snapped a picture just as Orville flew the first motor-driven airplane.

The Wrights flying careers began with gliders, testing them near Kitty Hawk, N.C., where winds were most favorable. The first gliders didn't have quite enough lifting power, so the Wrights went back to the drawing board. They built a 6-foot (1.8 m) wind tunnel for testing wing designs and began testing, and correcting, early theories of wing design. They built and flew nearly 1,000 gliders, solving most of the problems of balance in flight. Then they designed a powered plane.

The First Airplane

In 1903, for less than $1000, the Wrights built their first motor-driven plane. Flyer I had wings 40.5 feet (12 m) long, and with the pilot aboard, weighed about 750 pounds (340 kg). At Kitty Hawk, with Orville at the controls, the plane flew 120 feet (37 m) and was airborne for 12 seconds. Later that day, Wilbur flew the plane 852 feet (260 m) and was in the air for 59 seconds.

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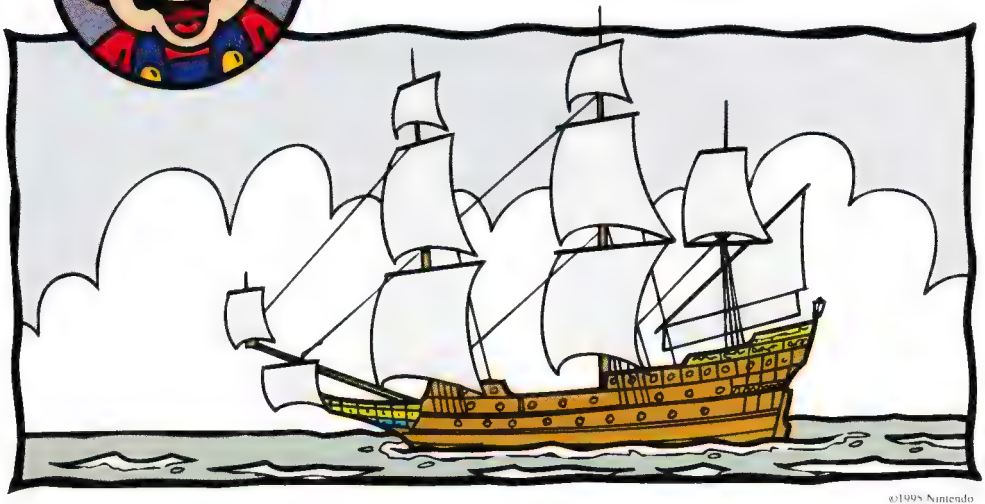
D3 054 16-04

Which was the largest 16th-century sailing ship?

BY AIR AND BY SEA

1. The schooner
2. The galleon
3. The catamaran



©1995 Nintendo

Galleon

A large ship with three or four masts and two or more decks, a galleon helped establish naval power. The Spanish used galleons to transport treasure found in the New World.

2 The galleon was the largest sailing ship of the 16th century.

Illustration © Musée de la Marine / Explorer Archives

Gold was loaded on galleons bound for Spain. But the big, heavy ships were hard to maneuver and often couldn't evade lighter pirate ships.

A strong ship, with sides 3-4 feet (.9-1.2 m) thick, a galleon had a heavy foremast and mainmast, both equipped with deep square sails. One or two smaller masts toward the rear of the ship had 3-cornered sails called lateens. A raised quarter-deck ran from the mainmast toward the ship's stern (rear), where the high poop deck was located. The square forecastle, a deck in front of the foremast, was low. The sides of the ship had openings to hold up to a dozen large guns.

Return to Spain

In the 16th century, after the discovery of the Americas, the Spanish had enormous fleets of galleons. The ships were built to carry home the gold, silver, and precious gems found in the New World. Many ships never made it back—they sank during storms at sea or during pirate attacks. Divers are still finding the wreckage today.

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D3 054 16-06

Where is the port of Rotterdam located?

BY AIR AND BY SEA

1. In France
2. In the United States
3. In the Netherlands

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Port

A port is a site on a waterway that provides shelter to boats. It's also where a ship's cargo can be loaded, unloaded, or stored. Rotterdam, the second largest city in the Netherlands, has one of the world's busiest ports.

3 The port of Rotterdam is located in the Netherlands.

Photo © J. L. Bohin / Explorer

In Rotterdam's immense industrial harbor, Europoort, there are facilities for storing oil or transporting it from tankers to nearby refineries.

In large ports, like Rotterdam, New York, San Francisco, and Hong Kong, ships from all over the world dock to unload and load food, cars, oil, clothing, computers, televisions, and other goods. These ports sometimes handle cruise ships as well. Small ports, such as those in moderate sized cities, are usually where fishing boats bring their catches and people anchor their pleasure boats.

Inland Ports

Many ports are directly on the coast with harbors that jut out into the ocean; others are not. Rotterdam is about 19 miles (31 km) east of the North Sea—not on the coast at all—but in 1872 engineers built a channel that linked Rotterdam with the sea and other large cities. The city has been one of Europe's primary ports ever since.

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D3 054 16-16

Which is used as fuel for jets?

BY AIR AND BY SEA

1. Kerosene
2. Methanol
3. Butane

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Jet Fuel

Kerosene, a thin oil distilled from petroleum, is used chiefly as fuel in jet engines. The kerosene remains liquid even at very low temperatures so it won't freeze when jets fly at high altitudes.

1 Kerosene is used as fuel for jets.

© E. Malglave / Explorer

Enough fuel is loaded to make sure the plane can reach its destination.

Kerosene is pumped aboard a jet at the rate of 234 gallons (900 liters) per minute. On long trips, planes may carry more than 102 tons (100 metric tons) of fuel, enough for a small car to circle the world 50 times.

Fuel Tanks

Depending on the type of jet, fuel tanks are located under the wings or under the fuselage. The tanks are perfectly airtight, with interior bulkheads or walls to prevent the fuel from sloshing around if the plane runs into turbulence in flight. Each tank is capable of supplying fuel to any of the jet's engines, by way of relays between tanks with a system of gates which the pilot controls. So a pilot can control how fast fuel is fed to the engines and distribute the remaining fuel within the tanks to balance the weight of the aircraft.

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How do pilots avoid turbulence in the air?

BY AIR AND BY SEA

1. By flying slower
2. By flying higher or lower
3. By dumping fuel

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Air Turbulence

When a plane's radar shows turbulence or stormy weather ahead, a pilot tries to avoid it. The pilot must consider the other traffic in the area and the instructions given by air traffic controllers.

In the nose of a commercial airliner is a radar device that can detect storms, aircraft, or other obstacles up to 248 miles (400 km) ahead—about 20 minutes of flight time. The radar signals bounce off planes and precipitation-filled clouds in their path.

Handling Turbulence

In the cockpit, the bounce-back radar signals show up as "blips" on a screen. If the blips show minor turbulence, the pilot lights the "fasten seatbelt" sign and tells passengers to remain seated for safety. Most large planes can fly right through minor turbulence. If the blips show heavy turbulence, the pilot contacts air traffic control to ask for updated weather information. If the turbulence is from a dangerous storm, the pilot may be rerouted around it. If the storm's not dangerous, the pilot may just be given permission to fly at a higher altitude to avoid it.

2 **Pilots avoid turbulence by flying above it or below it.**

© J. P. Nacivet / Explorer

Cloud formations the pilot can see also foretell turbulent weather.

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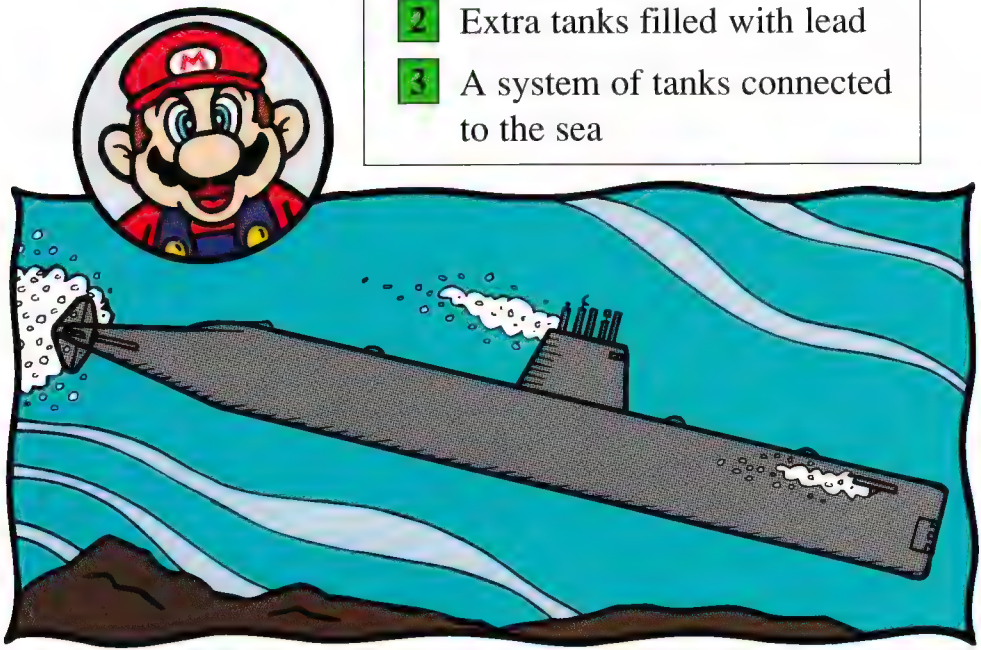
Which provides a submarine's ballast?

BY AIR AND BY SEA

1. Small side wings for diving
2. Extra tanks filled with lead
3. A system of tanks connected to the sea



©1995 Nintendo

Ballast

Ballast is the added weight in a submarine or ship that keeps it stable in the water. Without ballast, a sub wouldn't be able to dive or maneuver underwater. The concept of ballast follows the scientific principle of "displacement."

3 A submarine's ballast is provided by a system of tanks connected to the sea.

© D. Riffet / Explorer

The ballast tanks are located in the submarine's hull. The ailerons or winglike extensions regulate the boat's angle when diving.

An object floats in liquid when it weighs the same or less than the liquid it displaces, or pushes aside. If the object weighs the same or less, the liquid supports it. If the object is heavier than the liquid, the object sinks. So for a sub to submerge in water it must be heavier than the water. But a sub also needs to float on the surface, so it must be able to add or subtract weight as needed.

The Role of Ballast

When a sub's ballast tanks are filled only with air, the sub is lighter than water. To dive, the ballast tanks are opened allowing them to fill with water. This added weight causes the sub to dive beneath the surface. When the sub is ready to surface, the water is blown out of the ballast tanks with compressed air and the sub becomes light enough to float.

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How does a pilot know the best route to fly between cities?

BY AIR AND BY SEA

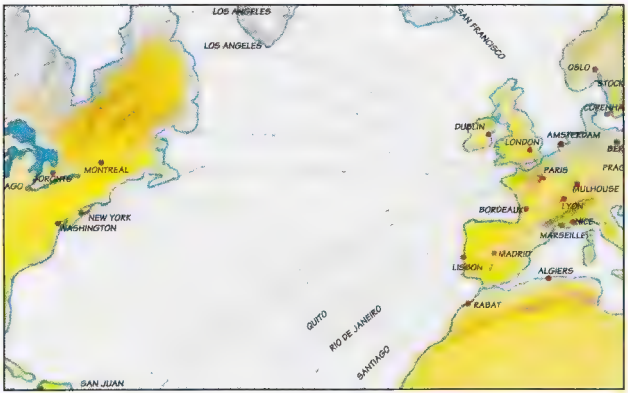
1. It's listed in the daily newspaper.
2. The pilot consults a psychic hotline.
3. With input from computers, radar, and air traffic controllers

©1995 Nintendo

Air Routes

Flights are planned by computers which report current information about the aircraft, its passengers, baggage, freight, fuel supply, and weather conditions between the departure point and destination.

3 **Computers, radar, and air traffic controllers help a pilot find the shortest, safest route between two cities.**



© J. Dang / Explorer

On long flights, air routes follow an arc since that's the shortest distance between two points on a globe.

The computer prints out several routes between the two cities, calculates the amount of time required for each, then picks the best. Sometimes several planes follow the same route, which can lead to heavy air traffic. Air traffic controllers direct the traffic from the ground.

Flyways

All air routes correspond with locations of air traffic control centers. About 200-400 miles (321-644 km) from each center, a plane is picked up on the center's radar. Air traffic controllers always know what planes are coming into or leaving their areas.

Pilots communicate with centers by radio to report the plane's location, receive updated weather reports, and sometimes to request permission to reroute or change altitude to avoid turbulence.

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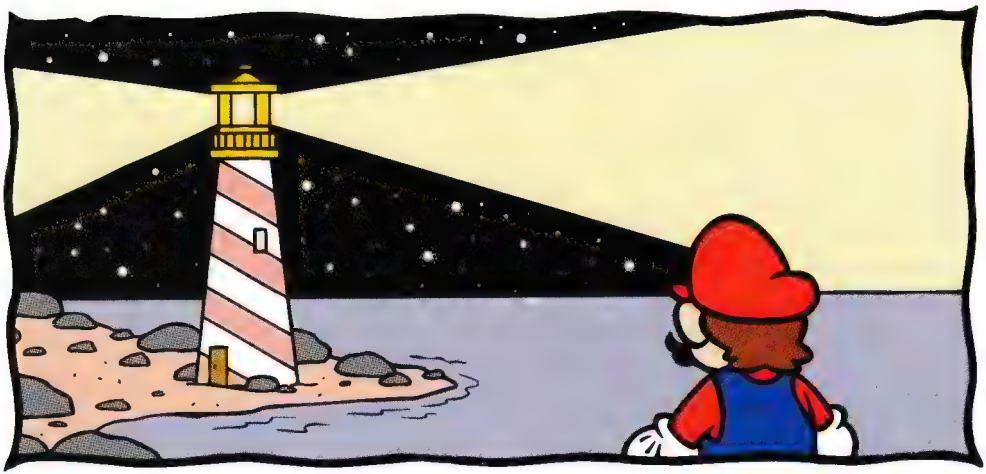
Where would you find a lighthouse?

BY AIR AND BY SEA

1. By a rocky beach
2. By a railroad tunnel
3. In a forest



©1995 Nintendo

Lighthouses

Lighthouses notify sailors that land is near and warn them of dangerous rocks and reefs.
Lighthouses are built at ports, on points, peninsulas, and rocks, and even in the sea on foundations sunk into underwater rock or coral.

1 **You would find a lighthouse by a rocky beach.**

© Ibo / Sipa Press

Lighthouses project light through lenses that increase the light's intensity. Some lenses can project light from one small bulb 20 miles (32 km).

The ancient Egyptians were the first to use light to guide ships at night, by lighting fires on hilltops. Later, during the reign of Ptolemy II (283-246 B.C.), they built the Pharos of Alexandria, the tallest lighthouse ever constructed. It stood over 400 feet (122 m) high and helped guide ships for about 1,500 years.

U.S. Lighthouses

In 1716, America's first lighthouse, the Boston Lighthouse, was built in the harbor of Boston, Massachusetts. By the early 1900s, about 1,500 lighthouses were operating in the U.S. The U.S. Coast Guard assumed administration of all lighthouses in 1939. Today, electronic navigational devices have taken over and the U.S. has only about 340 lighthouses. There are only about 1,400 lighthouses currently in use worldwide.

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Who was Magellan?

BY AIR AND BY SEA

1. A great Italian painter
2. A Portuguese explorer
3. A French explorer

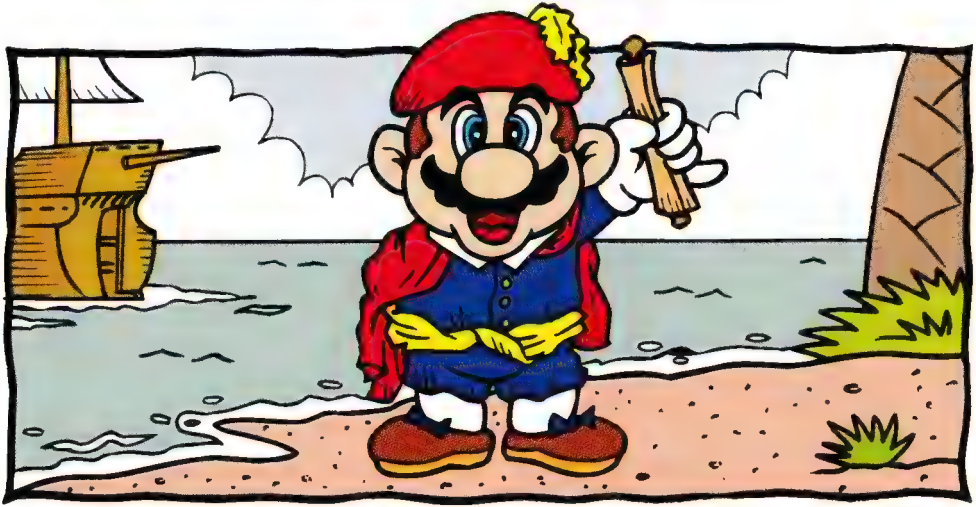

Illustration: Gary Fields

©1995 Nintendo

Magellan

Ferdinand Magellan (1480-1521) was a Portuguese explorer. He led the first around-the-world voyage.

2 Magellan was a Portuguese explorer who named the Pacific Ocean.

© E.R.L. / Sipa Icono

Magellan's voyage proved conclusively that the world was round.

At age 12, Magellan was sent to be a page at Portugal's royal court. There he learned the basics of navigation and in 1505, took his first sea voyage to India. To reach the Pacific, Magellan's ship sailed all the way around the southern tip of Africa and across the Indian Ocean. But young Magellan believed there must be a faster route. He wanted to lead an expedition to find it. When Portugal refused to fund his trip, he turned to Spain.

The Voyage Begins

Spain's King Charles I gave Magellan the money he needed, and on September 20, 1519 he left with five ships and 241 men. They sailed down the coast of South America and found an unknown passage through Chile to the Pacific. Today this passage is called the Straits of Magellan. Sadly, Magellan didn't survive the round-the-world trip. He was killed in the Philippines, and his crew completed the trip without him.

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Who was the first aviator to fly across the English Channel?

BY AIR AND BY SEA

1. Charles Lindbergh
2. Louis Blériot
3. Alan Shepard

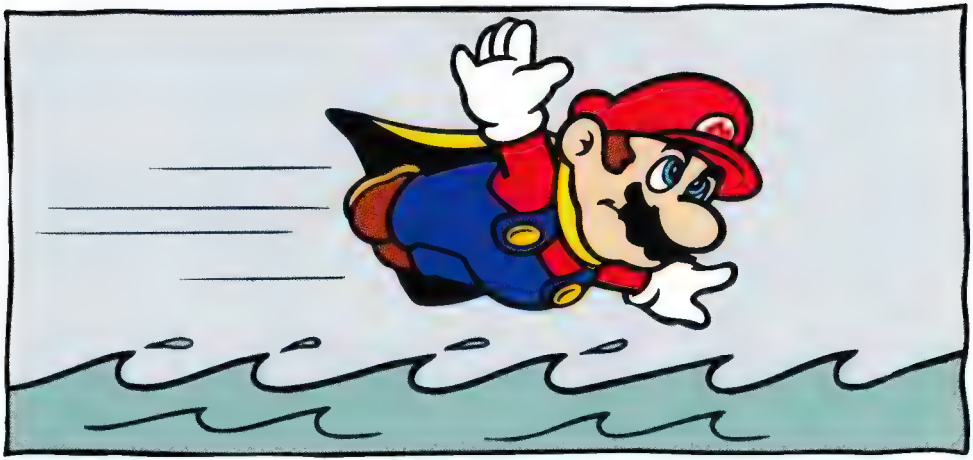

Illustration: Gary Fields

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Louis Blériot

On July 25, 1909, French pilot Louis Blériot (1872-1936) became the first person to fly across the English Channel which separates France and England.

2 Louis Blériot, a Frenchman, was the first aviator to fly across the English Channel.

© Larousse / Sipa Icono

Blériot soared past the white cliffs beside the 21-mile (34-km) English Channel between Dover, England, and Calais, France.

Blériot made a fortune in the auto headlight business before he became interested in airplanes. At age 30, he began designing planes and aircraft systems. A pilot control system he designed in 1908 is still used today. He also created the World War I S.P.A.D. fighter.

Blériot's Flight

For his historic flight, Bléroit flew a plane he designed and built. He was ill, but took his plane up so he could win the prize offered by the London Daily Mail to the first pilot to complete the flight. Plane engines in those days were undependable, overheating quickly, and usually misfiring after 20 minutes. Luckily for Bléroit, there was a light, cooling rain during his 37-minute flight, which kept his engine running evenly.

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Who was Amelia Earhart?

BY AIR AND BY SEA

1. A Broadway star
2. A famous pilot
3. A U.S. Olympic champion skater

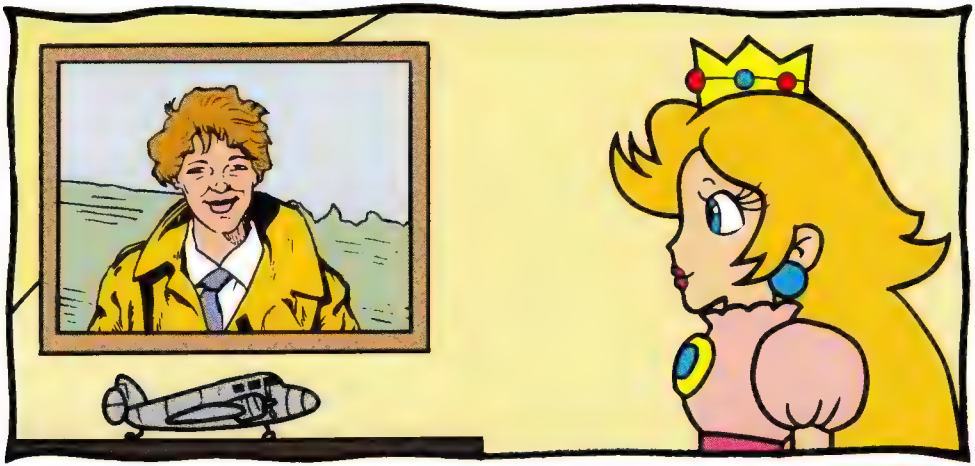

Illustration Gary Fields

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Amelia Earhart

Amelia Earhart (1897-1937) was an American aviatrix, or female pilot. In 1932 she became the first woman to fly solo across the Atlantic.

2 Amelia Earhart, a famous pilot, was the first woman to fly across the Atlantic Ocean alone.

© UPI, Bettmann

Amelia Earhart, like other pioneers in the early and mid-1900s, opened the way for more women to enter male-dominated fields.

Earhart began flying in 1918, and by 1922 was entering flying contests. In 1929 she helped to found the "Ninety-Nines," an international association of women pilots that still exists. She was the only woman to receive the Distinguished Flying Cross, a medal awarded to outstanding pilots by the U.S. Congress.

Lost at Sea

In 1937, on a flight around the world with her navigator Fred Noonan, Earhart's plane vanished near Howland Island in the Pacific Ocean. No trace of Earhart, Noonan, or their plane was ever found. Some people believe Earhart happened upon Japanese troops preparing for World War II and that she and Noonan were either taken prisoner or killed. This has never been confirmed, but the mystery of Amelia Earhart's disappearance still stirs people to look for answers.

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What is an AWACS?

BY AIR AND BY SEA

1. A tropical bird
2. A unique airplane
3. A female sailor

Illustration Gary Fields

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AWACS

The acronym AWACS stands for Airborne Warning and Control Systems. This unique airplane is also known as the E-3 Sentry.

2 AWACS is a unique airplane built by Boeing.

© Aimar / Sipa Press

AWACS fly far above battlefields, but can still monitor much of the acitvity on the ground.

AWACS are basically flying radar stations and air traffic control towers. The rotating "radome" on top of the AWACS houses special antennas. These antennas help to monitor all air and sea activities within the AWACS' wide range. AWACS are actually Boeing 707 airplanes which have been remodeled to house sophisticated electronic equipment.

A Flying General

AWACS is one of the most expensive jets ever built for the U.S. Air Force. This is not surprising when you think of all the radar, sensors, computers, high-speed communications equipment, and other costly components of this impressive plane.

Considering what the AWACS is capable of doing—detecting, identifying, and tracking planes, missiles, and ships during all kinds of weather and over all waters and terrain—the high cost of this flying battlefield management center seems to make sense.

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How long does it take to fly from New York to Paris in the Concorde?

BY AIR AND BY SEA

1. Six hours
2. Two and a half hours
3. One hour

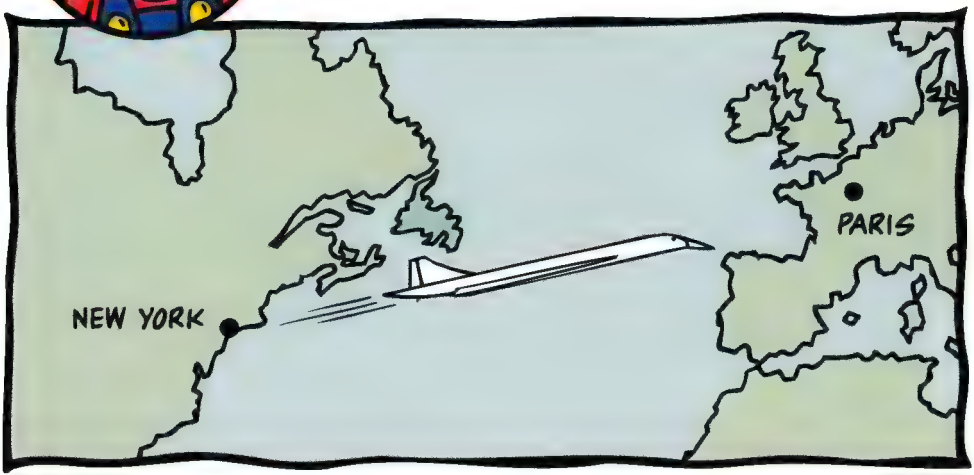

Illustration Gary Fields

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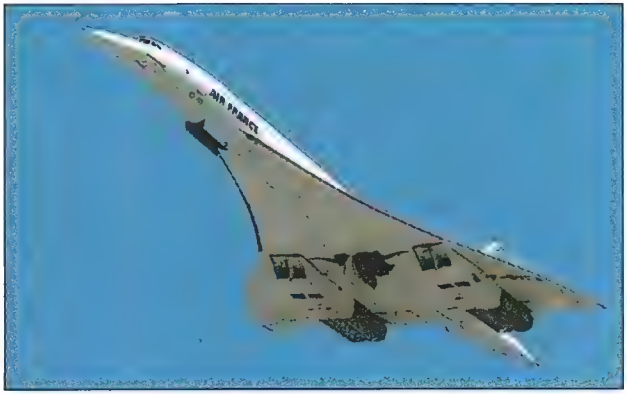
Concorde

The Concorde is the best-known supersonic transport (SST) and the fastest passenger plane in the world.

2 It takes two and a half hours to fly from New York to Paris in the Concorde.



© Renaudeau / Hoa Qui

The nose of the Concorde bends down to allow for a better view of the runway during landing.

The Concorde is the result of a 1962 joint project between the British and the French governments. It flies on the Sierra-Mike route, its own pathway carved out in the sky. High above any possible disturbance, such as strong winds, storms, or other aircraft, the Concorde cruises at altitudes of about 59,000 feet (17,900 m). Normal passenger jets don't usually go above 39,000 feet (11,830 m). When the Concorde reaches its maximum height, passengers can look out the window and see a curved horizon because the plane is so high!

Supersonic Speed

The Concorde is the only plane capable of flying at Mach speed, 2.04 or 1,320 miles (2,112 km) per hour—twice as fast as the speed of sound—while carrying passengers in utmost comfort. On the Concorde, everybody flies first class. Passengers spend most of their two and a half hours on board eating a gourmet meal.

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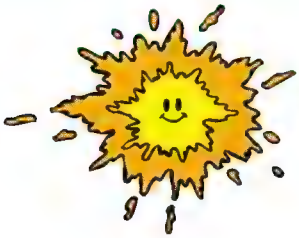
What country builds Boeing airplanes?

BY AIR AND BY SEA



1. France
2. Israel
3. United States of America

Illustration Gary Fields

©1995 Nintendo

Boeing 707

The Boeing 707, the first jet airliner, revolutionized the transportation industry following World War II. The 707 set the trend for an entire generation of aircraft powered by jet engines.

3 The United States of America builds Boeing airplanes.

© Len Sirman

With a capacity twice as large as the 707, the Boeing 747 can carry up to 500 passengers.

Boeing, the world's largest airplane manufacturer, is headquartered in Seattle, Washington. It was founded in 1916 under the name of Pacific Aero Products, but was renamed Boeing the following year after its founder William E. Boeing. Today the Boeing Company also designs and produces helicopters, space vehicles, hydrofoil boats, municipal railway cars, and missiles.

War Planes

The Boeing company began by manufacturing military aircraft during World War I. Its earliest craft was the "B&W seaplane," named for its creators, William E. Boeing and G. Conrad Westervelt. Later warplanes include the B-17, B-47, and B-52 bombers.

Boeing was also responsible for designing and building the first stages of Apollo/Saturn moon rockets and several space vehicles used to orbit the moon.

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D3 054 32-11

What is a cockpit?

BY AIR AND BY SEA

1. A mining cave
2. A farmyard bird
3. An airplane feature

Illustration: Gary Fields

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Cockpit

The cockpit, also known as the flight deck, is where the pilot, copilot, and crew sit in control of the plane during flight. The cockpit also houses many of the instruments, navigational aids, and controls necessary for the plane to function.

3 A cockpit is an airplane feature.

© P. Dumas / Sipa Press

The captain and copilot control the plane using the instrument panel in the cockpit.

Most planes have a "yoke," or control wheel, which controls the airflow over the movable control surfaces—ailerons, elevators, flaps, and rudders—all of which are necessary to change the plane's altitude and direction. Other planes have stick controls instead of yokes.

Flight Instruments

The number of instruments in an airplane depends on the number of engines the plane carries: The more engines, the more instruments. Flight instruments found in most cockpits include navigation and communication equipment, fuel supply and oil pressure gauges, and instruments which display and control the plane's speed, altitude, and position, or attitude. Jet-propelled planes also have thrust and exhaust temperature gauges.

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What is a container ship?

BY AIR AND BY SEA

1. A ship in a bottle
2. A ship that carries large amounts of goods
3. A fishing boat

Illustration Gary Fields

©1995 Nintendo

Container Ships

Container ships carry large uniform-size metal containers filled with goods, called cargo, from one port to another.

2 A container ship is a ship that carries large amounts of goods.

© Len Sirman

Container ships have revolutionized the cargo industry.

Large, fast, and efficient container ships have made the job of loading and unloading cargo much easier since their invention in the late 1960s. The first container ships were built in the United States.

Super Storage

Container ships typically carry 35,000 to 50,000 tons of cargo. Because all the cargo is packed in identical containers, loading the ship is relatively easy. To maximize loading space for the containers, the ship's engines and machinery are housed together in the bow, or front, of the ship. Containers are usually stored in an open space below the deck, known as the hold. They can also be stored on deck; three, four, or five high. A large container ship can transport up to 3,000 containers.

Ship to Shore

Uniform containers also make unloading the ship easier. Very often, containers are unloaded from the ships directly onto railroad cars, truck semi-trailers, or flatbed trailers which carry the cargo to inland destinations.

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For what was Charles Lindbergh famous?

BY AIR AND BY SEA

1. Flying
2. Painting
3. Dancing

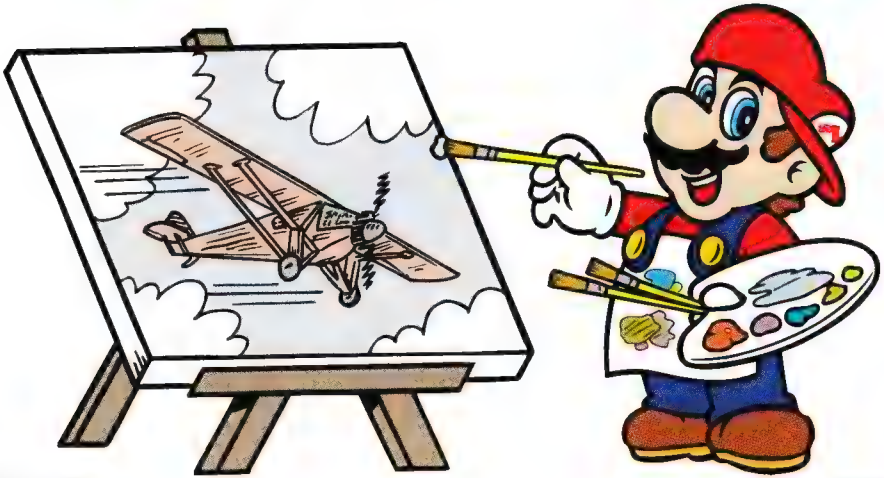

Illustration Gary Fields

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Charles Lindbergh

Charles Lindbergh made the first solo flight across the Atlantic Ocean in his plane *Spirit of Saint Louis*.

1 Charles Lindbergh was a famous aviator.

© Len Stirman

Lindbergh with his plane, *Spirit of Saint Louis*.

Charles Augustus Lindbergh (1902-1974) was born in Detroit, Michigan. At age 20, he began his career as a pilot carrying mail between St. Louis, and Chicago.

Prize Winner

In 1927, New Yorker Raymond B. Orteig offered a prize of $25,000 to anyone who could successfully complete a transatlantic flight from New York to Paris. Lindbergh accepted the challenge. It took him 33 hours and 32 minutes to fly nonstop from Roosevelt Field in New York to Le Bourget Airport near Paris. Lindbergh's flight brought him instant fame. In the name of goodwill, Lindbergh made flights over such places as the Yucatan and Mexico in 1929 and over the Far East in 1931.

Renowned Author.

Not only was Lindbergh a record-breaking aviator, he was also a renowned author. His book *We* (1927) tells the story of his historic flight, and his autobiography, *The Spirit of Saint Louis* (1953), won the Pulitzer Prize.

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Who was Donald Douglas?

BY AIR AND BY SEA

1. A Civil War general
2. An aircraft designer who founded his own manufacturing firm
3. A fast-food chain founder

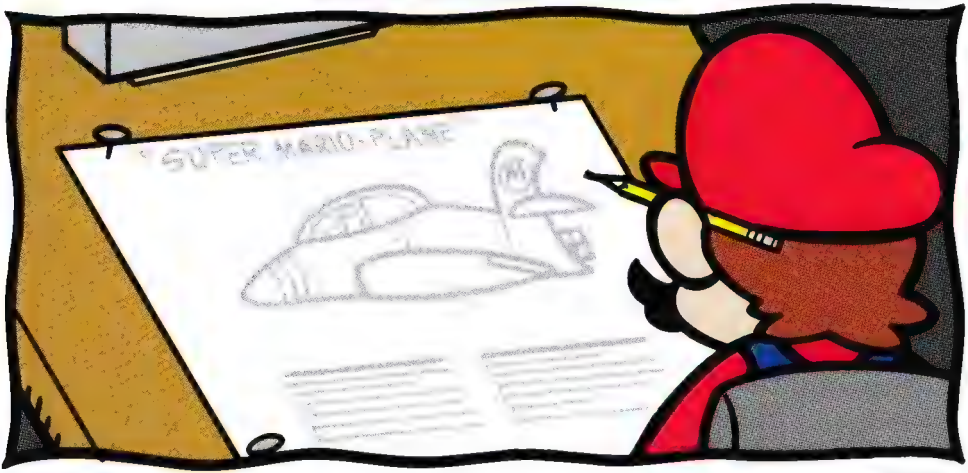

Illustration: Gary Fields

©1996 Nintendo

Donald Douglas

Donald Douglas (1892-1981) helped create the Douglas World Cruiser biplane, the first airplane to successfully complete an around-the-world flight.

2 Donald Douglas was an aircraft designer who founded his own manufacturing firm.

© Explorer

DC-3 airplanes were used in air combat in the Vietnam War. DC-10 airplanes are popular passenger planes.

Donald Douglas studied at the U.S. Naval Academy and Massachusetts Institute of Technology (MIT) where he helped build the world's first wind tunnel. In 1920, he established his own firm to design and produce military and civilian aircraft.

Industry Standard

By the late 1930s, the aircraft manufactured by Douglas' firm had become the industry standard for commercial airlines. The firm's airplanes were easy to pilot and had a solid but light frame that could withstand great pressure. During World War II, Douglas' firm designed and produced the A-20 (Havoc) and A-26 (Invader) light bombers and the SBD (Dauntless) dive bomber. After the war, the company manufactured the DC-8, DC-9, and DC-10 commercial jets. In 1967, the company merged with another to form McDonnell Douglas Corporation.

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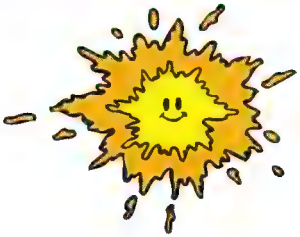
Who won the Battle of Trafalgar in 1805?

BY AIR AND BY SEA



1. The French
2. The Spanish
3. The English

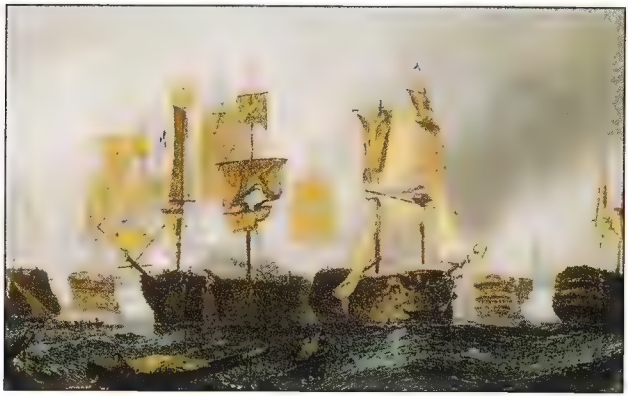
Illustration Gary Fields

© 996 Nintendo

Battle of Trafalgar

The Battle of Trafalgar was fought during the Napoleonic Wars, on October 21, 1805, west of Cape Trafalgar, Spain, between Cádiz and the Strait of Gibraltar.

3 Admiral Horatio Nelson won the Battle of Trafalgar, establishing British supremacy for more than 100 years.



© Explorer Archives

Nelson surprised Villeneuve, attacking his ships at right angles at Trafalgar.

A fleet of 33 French and Spanish ships under Admiral Pierre de Villeneuve fought a British fleet of 27 ships under Admiral Horatio Nelson. Villeneuve had received orders to leave Cádiz to support troops in Italy and hoped to reach the Mediterranean Sea without giving battle, but Admiral Nelson attacked Villeneuve's single line of ships heading north with two squadrons of his own ships from the west.

At 11:50 AM, Nelson signaled his famous message, "England expects that every man will do his duty." His ships shattered Villeneuve's line in a battle which ended at 5:00 PM. Villeneuve was captured, having surrendered 19 or 20 of his ships to the British. Though no British ships were lost, Admiral Nelson was shot and died at 4:30 PM, certain of his complete victory.

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Who was James Cook?

BY AIR AND BY SEA

1. A famous British veterinarian
2. A famous British explorer and navigator
3. A famous British astronomer

Illustration, Gary Fields

©1996 Nintendo

James Cook

James Cook (1728-1779), often referred to as Captain Cook, is famous for his exploration in the South Pacific and the North American coastal waters.

2 James Cook was a famous British explorer and navigator.

© J M Pechart/Diaf

In Australia, Cook found the Aborigines, kangaroos, and eucalyptus.

In 1768, Cook made his first great voyage to the South Pacific and proceeded to New Zealand, where he took formal possession of parts of both main islands and accurately charted 2,400 miles of coastline for the first time. In 1770, he discovered the eastern coast of Australia, which he charted and claimed for Great Britain under the name of New South Wales. On January 16, 1773, he made the first crossing of the Antarctic Circle. In 1776, Cook set out to determine whether a Northwest Passage between the Atlantic and Pacific oceans existed north of the North American continent. Early in the expedition he discovered and charted some of the Sandwich Islands, later renamed the Hawaiian Islands. He traveled north to the coast of present-day Oregon, later charting the western coastline until ice forced him to turn back. He returned to the Sandwich Islands where he was killed in a fight with islanders over the theft of a boat.

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What is “trim” in nautical terms?

BY AIR AND BY SEA

1. The back deck of a sailboat
2. The relation of the sails to the direction being sailed
3. A hard northeasterly wind

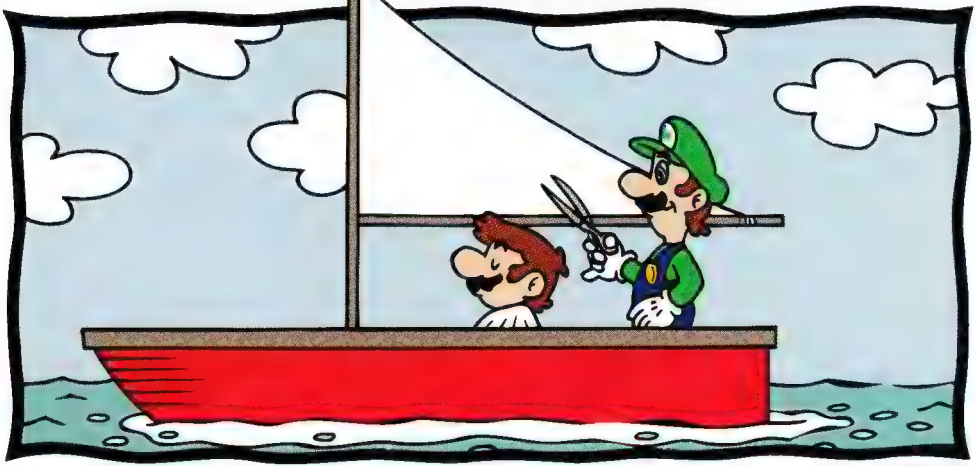

Illustration: Gary Fields

©1996 Nintendo

Nautical Trim

Trim is the adjustment of the sails, rigging, and other navigational tools according to the direction of the wind and the course of the ship.

2 **Trim refers to the direction the boat is sailing and the set of her sails.**

© L. Maquet

Technically speaking, a craft less than 65 feet (20 m) in length is considered a boat; longer crafts are considered ships.

Boats are classified primarily by their method of propulsion. For example, there are sailboats, whose sails trap and use the wind to propel the boat forward. There are also motorboats, whose motors may be either outboard, that is hanging into the water on the outside of the boat, or inboard, hidden below the deck, much like under the hood of a car. In rowboats, people use oars or paddles to move forward in the water. Boats may also be categorized according to function, the way in which they are built, and the type of materials used.

Boats or Ships?

A large watercraft is properly called a ship; however, the boundary between boats and ships cannot be clearly defined. Some larger vessels today are called boats, even though they are longer than some ships of colonial America.

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What is heeling in nautical terms?

BY AIR AND BY SEA

1. Bringing one boat alongside another
2. Forming a line of boats
3. A boat leaning to one side

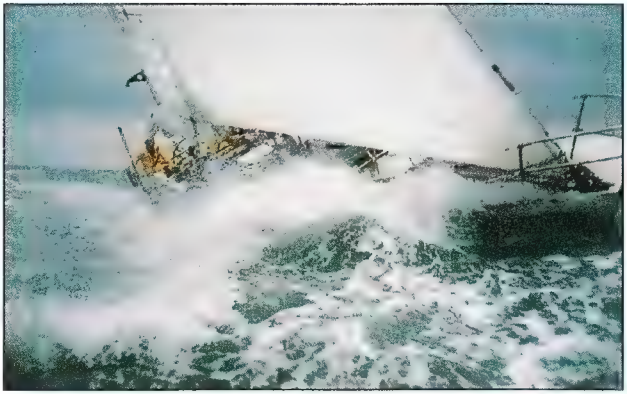
Illustration Gary Fields

©1996 Nintendo

Heeling

Those on a sailboat pay attention to any sudden movement which might cause someone to fall overboard. Heeling can be a normal part of sailing, but it may be dangerous.

3 Heeling describes a boat leaning to one side.



© Ph. Plisson / Explorer

Even in waters that are calmer than these, fishing a person out of the sea takes skill.

A boat is said to be heeling when it leans to one side. Heeling is not always dangerous and it can even be exciting, but it is best to be careful in a fast-moving boat or in rough waters. That is why sailors take care to move safely while on board a boat.

Man Overboard

Sailors know the importance of reacting with lightning speed if a person falls overboard. Often, a buoy—a special floating device— will be thrown into the water to help rescue someone. If a person is strong, knows how to float or to swim, has learned water safety procedures, and stays calm, he or she has a better chance of being located and rescued.

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What is rigging in nautical terms?

BY AIR AND BY SEA

1. The first time the sails are used
2. Devices used to support the mast and sails of a boat
3. Supplies for a long sea voyage

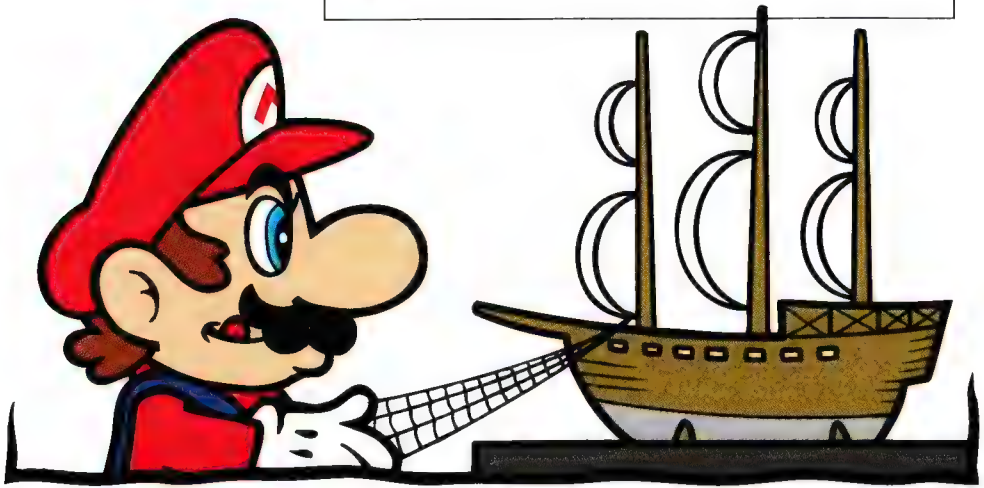

Illustration Gary Fields

©1996 Nintendo

Rigging

Rigging can also refer to the sails themselves as well as to their support system. On ships without sails, rigging is used to hold equipment.

2 **Rigging refers to the ropes, chains, and other devices used to support the mast and sails of a boat.**

© L. Maquet

Boat-lovers often gather to hold regattas, or boat races, which gives them opportunities to admire each other's vessels.

The rigging of a particular boat depends on its function. Is it a fishing boat? Is it a slow-moving freighter used to carry cargo or is it a speedy clipper? Is it used in racing or for pleasure cruises? Some boats have complex rigging, others may not have any rigging at all.

Rigging Basics

The basis for all rigging is the mast, which is generally made of wood or metal. The mast is the tall structure on the boat which supports the sails, and it includes the ropes, chains, yards, and other devices used for changing the size and position of the sails to best make use of the wind. (Yards are special poles, called spars, to which some sails are attached.)

The mast may also support lookout platforms called crow's nests or other devices such as communications equipment or lights.

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What are nautical flags?

BY AIR AND BY SEA

1. Signal flags used to communicate between vessels
2. Decorative flags used on vessels
3. Banners used on racing vessels

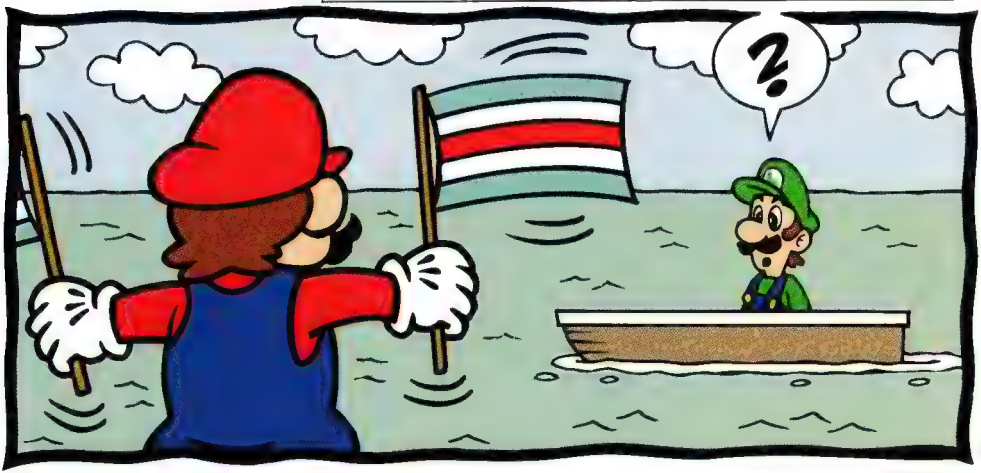

Illustration: Gary Fields

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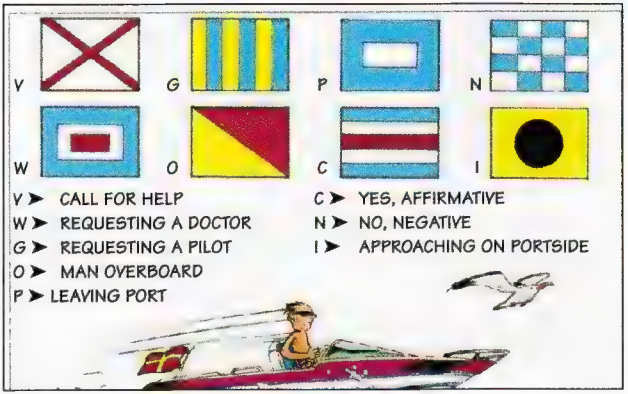
Nautical Flags

The designs on nautical flags are part of an official international code used to communicate status, country of origin or even danger.

1 Nautical flags are signal flags used to communicate between vessels.



© Y. Tabariés

National flags on board ships must be flown from eight in the morning until sunset. These are illustrations of some of the signal flags used in nautical communications.

We have used nautical flags to communicate since ancient times—long before the invention of the modern electronic communication devices found on board many modern ships. In fact, such flags are still in use.

Of course, national flags identify the country in which a ship is registered, but signal flags may also used to send specific messages—to communicate status, a request for help or a specific need such as SOS, man overboard, or send medical help.

Today, the term SOS refers to any call for help, not just one sent by the crew of a ship.

International Code

In the past, the meanings of signal flags varied widely and many have evolved over time. That is why it was considered important to adopt an international code of standardized signals. Such a code was officially adopted in 1900.

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What is the Caravelle?

BY AIR AND BY SEA

1. A French luxury ocean liner
2. The first French passenger jet
3. A French luxury car

Illustration: Gary Fields

©1996 Nintendo

Caravelle

The Caravelle, manufactured in France from 1955 to 1972, was a high-flying passenger jet designed to reduce fuel consumption. Its unique design was widely imitated.

2 The Caravelle was the first French passenger jet.

© P. Gleizes / Explorer

Note the sleek design of the Caravelle jet, the first plane to rely on semi-automatic pilot in conditions of reduced visibility.

The Caravelle, a passenger jet began flying in 1959. It was unique in many respects. The new plane was admired for its classic, aerodynamic design. To reduce noise, the jet-engines were located behind the fuselage—the central part of the plane containing its passenger and cargo compartments, wings, and tail.

The Caravelle was capable of covering a maximum distance of 1,863 miles (3,000 km) at a top speed of 528 miles per hour (850 km/h).

Faster Than Sound

Did you know that sound travels through air at about 740 miles per hour (1,200 km/h)? This figure can be expressed as Mach 1. The more recent supersonic transport, the Concorde, flies at 1,550 miles per hour (2,496 km/h)—a little more than twice the speed of sound, or Mach 2.03. The Concorde was a joint project of France and Britain.

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What determines the flight path of an airplane?

BY AIR AND BY SEA

1. Wind
2. Air traffic controllers
3. Signals from the cockpit

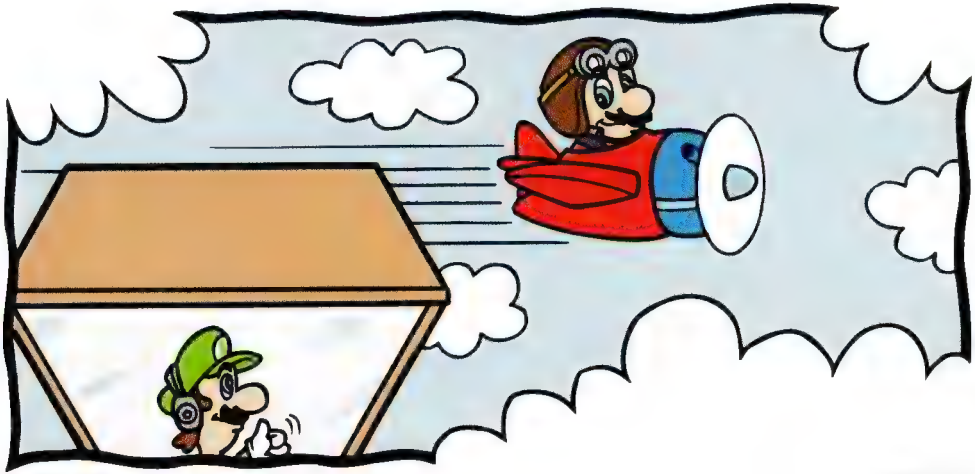

Illustration: Gary Fields

©1996 Nintendo

Air Space

Air traffic controllers keep track of all airplanes flying at different speeds and altitudes, and must make sure that they do not collide.

2 The path of an airplane in air space is controlled by air traffic controllers.

© E. de Malglaive / Explorer

Computer tracking of aircraft has made air traffic control more accurate, but the people using it are still responsible for passengers' safety.

The airport traffic control tower manages handling, takeoffs, and all movement within the airport terminal control area. On the ground, the controller guides airliners from the loading ramp, along the taxi strips, and up to the runway. The controller must also consider all the ground activity that is going on: fuel pumping, luggage and cargo loading, and maintenance of the aircraft.

Stressful Work

Air traffic control is stressful work. A controller is responsible for making sure that flight patterns are safe and efficient. In 1981, air traffic controllers across the United States went on strike, and civilian (nonmilitary) air travel ground to a halt. Since then, steps have been taken to make their jobs less stressful. For example, aircraft cannot take off until a landing slot has been reserved for it at its destination. This means that the controllers do not have to try to find slots for planes as they are coming in.

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What is a plane's "lift"?

BY AIR AND BY SEA

1. Its launching pad
2. Its support in the air
3. Its engines

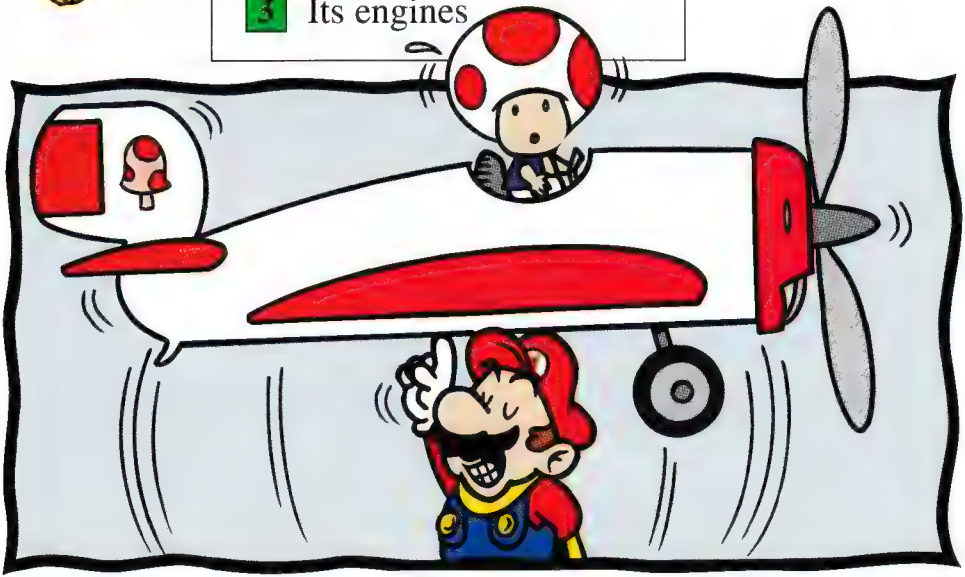

Illustration Gary Fields

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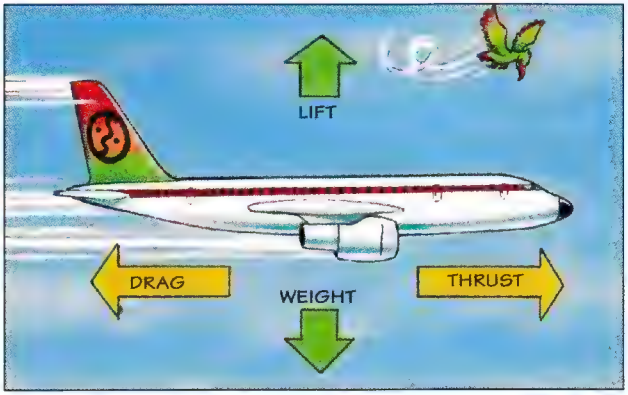
Lift

Aircraft are much heavier than air, so they need lift to counterbalance their weight during flight. Planes use the airflow around them to keep them aloft.

2 A plane's "lift" is its support in the air.



© Y. Tabanés

The most critical element in a wing's ability to produce lift is its cross-sectional shape.

An aircraft flies when the lift, or upward force created by the wing, increases to a value larger than the aircraft's total weight. The wing is the most important lift-producing element of an aircraft. Wing designs vary, depending on the aircraft type and purpose. Propeller-driven aircraft normally have an all-metal straight wing with a thick curve. Jets have swept-back wings of medium curve that reduce drag and improve performance at high speeds. Early aerodynamic research on kites and gliders showed that a flat plate would produce lift, but that more lift could be produced if the plate tilted slightly into the wind. That's why an airplane's wings are slightly tilted.

Forward Thrust

While wings help keep the plane aloft, engines and propellers drive it forward. Jets use the energy of rapidly expanding gases to push the plane through the air. Smaller planes, like turboprops, use a propeller.

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What is jibing?

BY AIR AND BY SEA

1. Landing a plane
2. Sailing technique
3. Method of rowing

Illustration: Gary Fields

©1996 Nintendo

Sailing

Sailboats use the wind not only for forward motion, but also for changing direction. Jibing is a difficult technique used to tack, or change direction, using the wind astern, or behind, the boat.

2 Jibing is a technique used to change direction while sailing.

© Merpool / Explorer

When jibing, the boat must be kept in balance while the sail is being shifted from one side to the other.

To jibe successfully, the boat must be kept balanced while the sail is shifted from one side to the other. This technique is the fastest way to change direction, because the rear wind gives the boat its best momentum, or push. The wind and the boat move in the same direction, with the sails positioned perpendicularly, or at right angles, to the direction of motion. Tacking with the wind astern, or behind, the boat is a tricky move. That's because the boat does not slow down as it would using a head wind, or wind coming toward the bow, or front end, of the boat.

How It's Done

To jibe, the boat must be flat in the water, and the crew must be ready to move to the windward side of deck to keep it balanced. The boat will usually rock while the sail crosses to the other side.

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Who was the first person to sail around the world alone?

BY AIR AND BY SEA

1. Joshua Slocum
2. Amelia Earhart
3. Jacques Cousteau

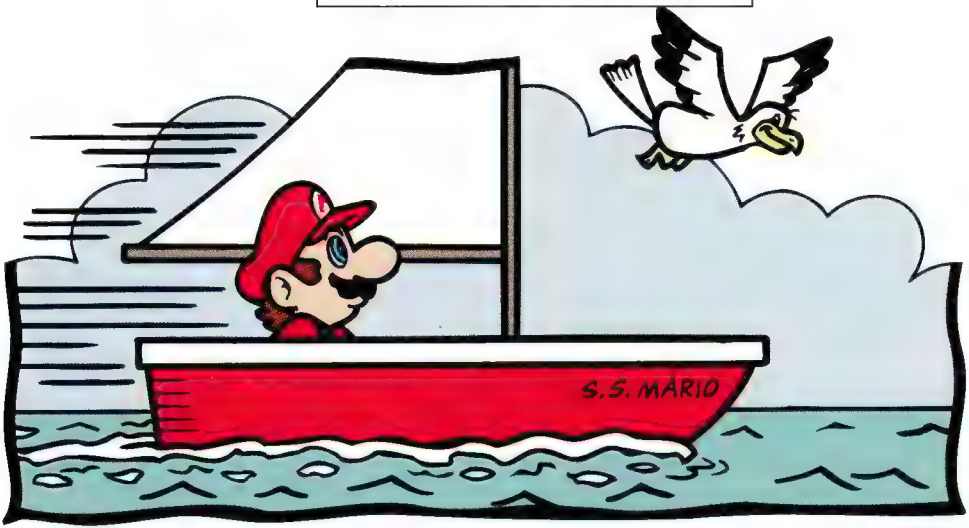


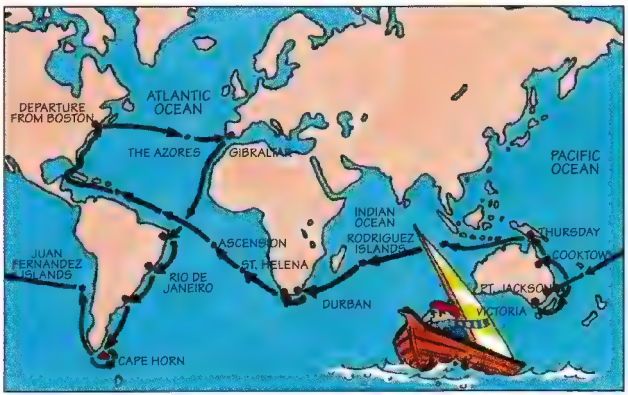
Illustration: Gary Fields

©1996 Nintendo

Joshua Slocum

Published in 1900, Joshua Slocum's book *Sailing Alone Around the World* chronicles his trip. His story made him famous and brought him considerable wealth.

1 Joshua Slocum was the first person to circumnavigate the world alone in a sailboat.



© Y. Tabarés

Joshua Slocum hoped to find glory when he returned from his trip around the world, but the war between Spain and the U.S. took center stage. He wrote a best-selling book about his adventures.

Joshua Slocum (1844-1909 or 1910) spent most of his life at sea. He worked as a ship's cook when he was fourteen and was a sailor by the time he was eighteen. He later served as captain of several ships.

From 1895 to 1898, he sailed around the world in the *Spray,* a restored 19th-century fishing sloop. During his trip he encountered pirates, tornadoes, and hail, but the biggest challenge he faced was loneliness. To pass the time, he sang to himself and gave orders to a make-believe crew! Slocum retired on Martha's Vineyard, an island off the coast of Cape Cod, Massachusetts.

Disappearance

In late 1909, Slocum set out alone for the Cayman Islands in the Caribbean Sea. Apparently a victim of a shipwreck, Slocum and his ship were never seen again.

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What is buoyancy?

BY AIR AND BY SEA

1. The ability to float
2. The capacity to carry heavy loads
3. The weight of a sailing vessel

Illustration: Gary Fields

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Buoyancy

In order to float, an object must sink in water until it has displaced an amount of water weighing the same as it. This is why a ship's weight is an important consideration for a ship designer.

1 Buoyancy is the ability to float.

© FourByFive, Inc

An air-filled flotation device allows this swimmer to float on the water's surface.

Besides being buoyant, a boat must be stable. The weight on board must be distributed so that the boat won't sink at one end. For example, the weight of an outboard motor must be offset by placing an equal weight at the forward end of the boat or by broadening the end of the boat where the motor sits.

Another concern in building a boat is structure. A boat must retain its shape despite strong waves and heavy internal weight, such as cargo.

Keeping Water Out

Boats must also be watertight. Boats constructed of wooden planking are caulked with a gluelike material that seals the cracks between planks. Many boats today are molded from fiberglass. Since they have no seams, fiberglass boats are automatically watertight and need no caulking.

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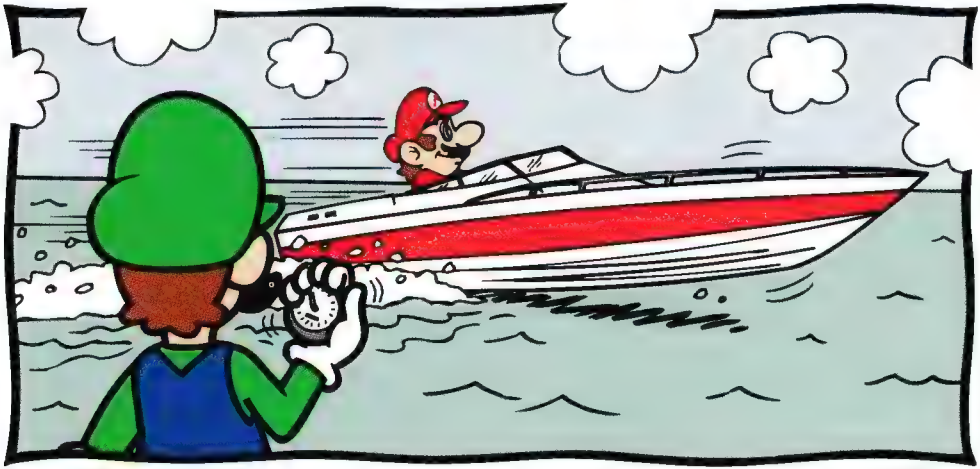
How are motorboats powered?

BY AIR AND BY SEA

1. Wind or solar energy
2. Gasoline or diesel fuel
3. Butane or kerosene



Illustration, Gary Fields

©1996 Nintendo

Motorboat

Smaller boats are usually powered by gasoline engines, while larger ones run on diesel fuel. The motorized speedboats used in races have especially powerful motors.

2 Motorboats run on gasoline or diesel fuel.

© Len Sirman

Speedboats like these, which use a lot of power, usually are propelled by inboard/outboard motors.

Different types of motorboats are distinguished by size, hull structure, engine type, and engine placement. Motorboat engines are mounted inboard, outboard, or inboard/outboard.

Engine Placement

Inboard motors are permanently mounted inside a boat's hull. They turn a large shaft extending through the boat's hull into the water. A propeller attached to the end of the shaft pushes the boat through the water. Boats with inboard motors are steered with a rudder.

Outboard motors are mounted outside the boat's hull, usually at the stern, or back end. Outboard motors run a propeller through a series of shafts and gears. Inboard/outboard, or I/O, motors are mounted on the inside of the boat's hull, but the device that powers the propeller resembles an outboard motor drive. As with an outboard motor, the boat can be steered by turning the entire drive unit.

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What are tugboats used for?

BY AIR AND BY SEA

1. Transporting people and cars
2. Towing or pushing barges and ships
3. Deep sea fishing

Illustration: Gary Fields

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Tugboat

Tugboats have powerful motors to make them strong enough to push or pull large vessels in ports and offshore. The first tugboats, used in the early 1800s, were powered by steam.

Tugboats are used to tow or push barges and large ships.

© Sctfcow. / Sipa Press

Tugboats are sometimes needed to rescue or guide ships.

The first tugboat was the Charlotte Dundas. Built in 1802 by Scottish engineer William Symington, the boat was equipped with a Watt steam engine that turned a paddle wheel that, in turn, propelled the boat. In about 1850, engineers in the United States designed tugboats driven by propellers instead of paddlewheels. Diesel fuel replaced steam by 1900.

Modern Tugboats

While tugboat size—ranging from 70 to 210 feet (21 to 64 m) long—has changed little in the past century, motor strength has greatly increased.

Berthing tugs, used to move large ships in and out of docks, are now built with strong wooden hulls to resist damage.

Tugs are used with non-powered, or dumb, barges in inland waterways. In Europe, tugboats generally pull a group of barges connected by a towline, while in the United States tugs push groups of barges.

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What is a sextant?

BY AIR AND BY SEA

1. Gale force wind
2. Six-legged shellfish
3. Device for measuring distance

Illustration: Gary Fields

©1996 Nintendo

Sextant

Two people invented the sextant separately in about 1730: English mathematician John Hadley and American inventor Thomas Godfrey.

3 A sextant is an instrument used to measure distance on land, in the air, and at sea.

© DR / Jerrican

Sextants are composed of the arc of a circle marked in degrees and a mobile arm that pivots from the circle's center. A telescope mounted to the frame is used to view the object whose distance is being measured.

The first sextants were used in the mid-18th century. Early sextants were hand held and lined up with the horizon, or pointed where the ocean meets the sky.

How They Work

Using a modern sextant, the observer looks through a telescope at the object whose distance is to be measured. Light from the object is reflected in two mirrors on the sextant, one fixed and one adjustable. The adjustable mirror is rotated to line up the reflected image with the horizon. The degree to which the mirror must be rotated gives a measure of the object's altitude on the calibrated limb.

An artificial horizon must be created in order to accurately measure the distance of an object from land or from the air. Some sextants used for aircraft navigation have a bubble encased in fluid to create an artificial horizon. Others are equipped with a pendulum or a gyroscope.

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What are the "flukes" of an anchor?

BY AIR AND BY SEA

1. Markings for identification
2. Devices that add weight
3. Parts that secure the anchor to the ground

Illustration Gary Fields

©1996 Nintendo

Anchor

In ancient times, anchors were made from large stones, sacks of sand, or logs weighted with lead. Today they are made from metal or cement.

3 The flukes of an anchor dig into the ground to secure it.

© Chandelle / Jerrican

Some ships have an anchor attached to a chain for raising and lowering it. The opening on the ship through which the chain is drawn is called the "hawsehole."

Anchors are used to hold buoys, boats, and ships stationary either by their own weight or by digging into the ocean floor, riverbed, or lakebed. They are attached to the buoy, boat, or ship with heavy ropes, cables, or chains and often consist of a single or double hook.

Anchors Throughout History

Early anchors were very simple, consisting of baskets of rocks, lead-weighted logs, or three or four long poles tied together with wooden hooks at one end. The poles were called the shank, and the hooks formed the crown. A crosspiece called the stock, attached to the top of the shank, tilted the anchor against the sea bottom to make the hooks catch and dig in.

Later, when iron was introduced into anchor construction, anchors were made with teeth or U-shaped flukes and removable stocks.

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What are territorial waters?

BY AIR AND BY SEA

1. Pure water from underground springs
2. Areas of ocean controlled by a country
3. Bodies of water that belong to all nations

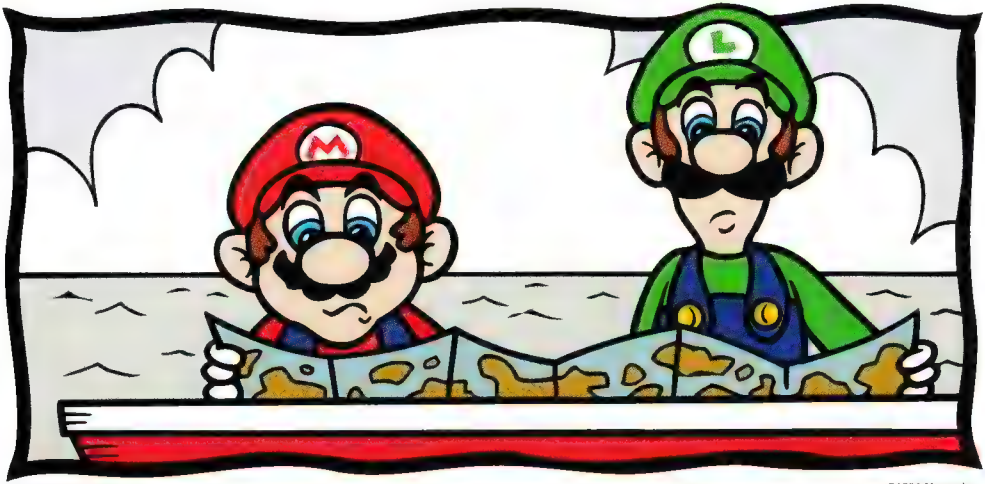

Illustration Gary Fields

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Territorial Waters

Territorial Waters, as distinguished from the high seas, include waters within a country, waters that form boundaries between countries, and coastal waters. A nation's control over a certain body of water includes the air space above and bed beneath the waters.

2 Territorial waters are parts of the ocean that are controlled by the country they are closest to.

© P. Delurbe / Explorer

No nation can exercise rights in the territorial waters of another nation without permission. A country can refuse to allow foreign ships to fish in its waters and can forbid the entry of foreign armed vessels.

Until the 1950s, it was agreed that the limit of a country's territorial waters was 3 nautical miles (5.6 km) from the low-water mark. After the 1950s, various nations claimed limits beyond 3 nautical miles.

When some countries extended their territorial waters after World War II, a series of international disputes arose. In 1982, the United Nations Convention of the Law of the Sea, drafted an accord stating that coastal nations could claim territorial waters of up to 12 nautical miles (22 km) and an exclusive economic zone of up to 200 nautical miles (373 km).

Not all nations accepted the accord, and there is still no formal agreement over the limit of a nation's territorial waters.

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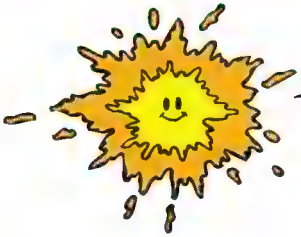
What kind of boat did Columbus sail to the New World?

BY AIR AND BY SEA



1. Steamship
2. Caravel
3. Frigate

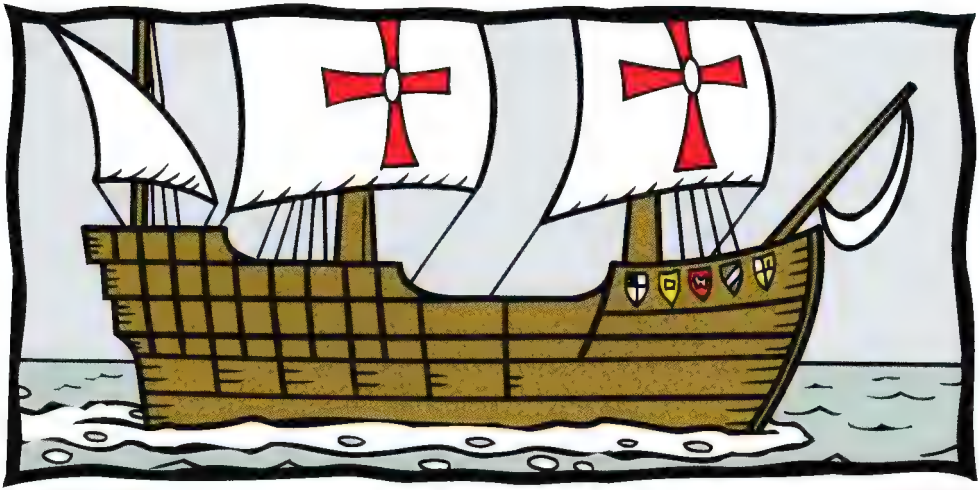


Illustration Gary Fields

©1996 Nintendo

Caravel

The caravel was a small sailing ship used primarily by Spanish and Portuguese explorers. Christopher Columbus's fleet consisted of the decked ship Santa Maria and two caravels, the Nina and the Pinta.

Most historians believe that the Santa Maria was 75 to 90 feet (23 to 27 m) long. The smaller Nina and Pinta were 70 to 75 feet (21 to 23 m) long. Columbus and his 90-man crew sailed these ships to the New World in about 5½ weeks.

Columbus's fleet set sail from Palos, Spain on August 3, 1492. Early in the morning of October 12,

2 Christopher Columbus sailed to the New World on a caravel.

© J.-P. Couran / Explorer

With a broad bow and high, narrow deck, each caravel had three or four masts. The foremast carried a square sail, while the others bore triangular lateen sails.

Columbus and his crew landed on Guanahaní, an island in the Bahamas. Columbus claimed the island for Spain and named it San Salvador, meaning holy savior. In the following weeks, the crew landed on numerous other islands, all the while believing they were in Asian waters.

After fighting through severe storms off the coast of Portugal, they arrived back in Palos, Spain in March of 1493. There, Columbus received a royal welcome and many honors.

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What ship was responsible for the first oil spill?

BY AIR AND BY SEA

1. Torrey Canyon
2. Amigo Cadiz
3. Olympic Bravery

Illustration: Gary Fields

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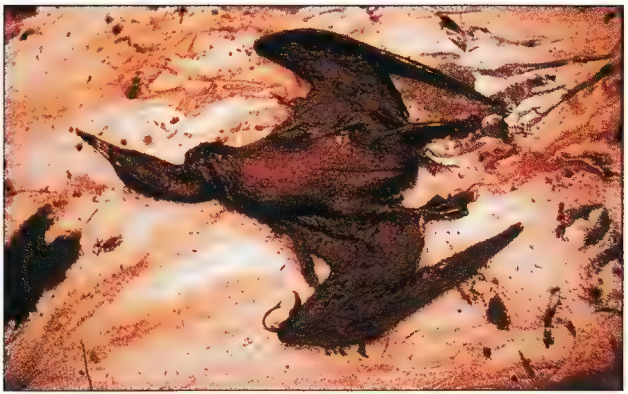
Oil Spill

The most catastrophic oil spills are the result of tanker accidents at sea. The wreck of the Torrey Canyon off the coast of Great Britain in 1967 resulted in the first oil spill in history.

1 The first oil spill was caused by the oil tanker Torrey Canyon.



© Len Sirman

Oil spills greatly harm the animals living in and around the ocean. Oil-coated birds can no longer fly, and shellfish that ingest oil-tainted water become toxic to eat.

Oil spills can kill waterfowl and other animals. Oil dissolves the protective coating on a bird's feathers, which prevents flight. Oil has a similar effect on the fur of ocean mammals like the sea otter. Oil spills may completely wipe out some species of animal, eventually upsetting the ecological balance of an area.

Recovery and Clean Up

Some waters are more vulnerable than others: The water of the Mediterranean Sea, for example, is renewed very slowly. Any oil spill there has drastic consequences.

Oil spills at sea must be cleaned up quickly, before wind and waves spread and thin out the oil. Floating booms may be used to contain the oil until it can be removed with pumps or skimmers. Oil on the surface may be burned off. Chemical dispersants can be sprayed on affected areas to break down the oil.

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How do planes take off from aircraft carriers?

BY AIR AND BY SEA

1. By their own power or by catapults
2. With missiles that they drop later, in flight
3. Using the force of ocean winds

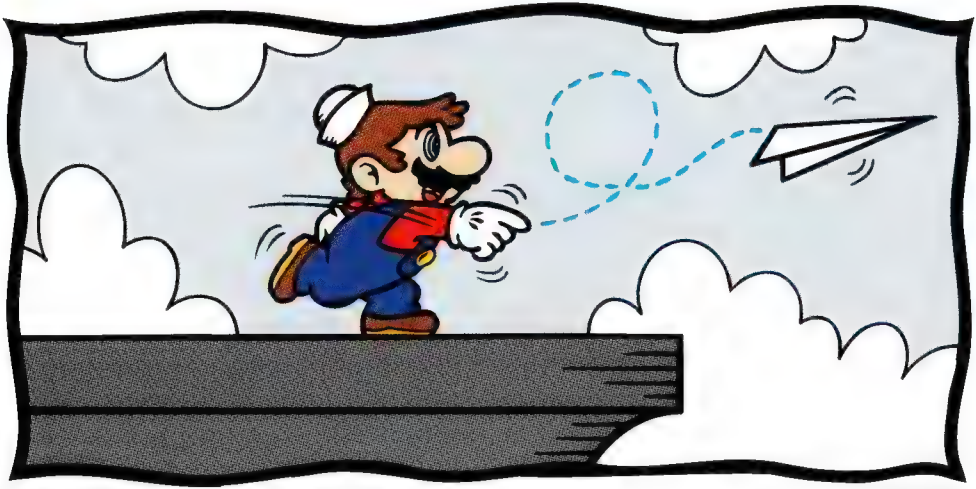

Illustration: Gary Fields

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Aircraft Carrier

Aircraft carriers are not simply floating runways. They are mobile air bases, containing electronic instruments and living quarters for personnel.

1 Planes on aircraft carriers take off by their own power or are launched by catapults.

© Len Sirman

Planes are stowed below the landing deck on an aircraft carrier. They are moved up to the flight deck with elevator lifts.

In 1989, the U. S. had the world's largest fleet of aircraft carriers. One of these ships, the *Nimitz*, is 1,092 feet (332 m) long. It can accommodate 90 planes and a crew of 6,300 people. Because its flight deck is angled, one plane can take off while another lands.

By the late 1980s, the former Soviet Union had four Kyyiv carriers. Each is 899 feet (274 m) long. Designed for submarine warfare, they are equipped with helicopter and vertical-takeoff-and-landing (VTOL) aircraft. Unlike ordinary planes, VTOL aircraft don't need a runway to take off or land. They rise straight up into the air and descend straight down.

By the late 1980s, Great Britain had three carriers designed for antisubmarine warfare and command control missions. France had two carriers built in the 1950s and one nuclear-powered carrier.

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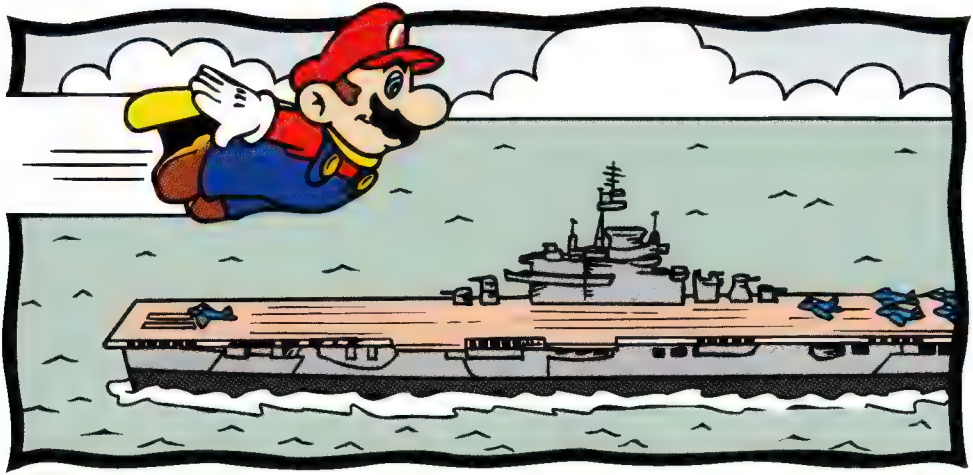
What was the name of the first aircraft carrier?

BY AIR AND BY SEA

1. *Pegasus*
2. *Argus*
3. *Birmingham*



Illustration, Gary Fields

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Aircraft Carrier

The *Argus* was converted from a British passenger liner in 1918. Its flight deck extended from bow to stern—front to back.

2 The first true aircraft carrier was the British Royal Navy's HMS Argus.

© Wysocki / Explorer

Apart from aircraft carriers, a country's naval forces may include nuclear submarines and destroyer ships.

Although the *Argus* was the first true aircraft carrier, airplanes had taken off from and landed on ships before. The earliest airplane flight from a ship occurred in 1910 from the USS cruiser *Birmingham*. Two months later, a plane landed for the first time on a ship, the USS *Pennsylvania*. The HMS *Hermes*, a British cruiser, was converted to carry aircraft in 1913. Takeoff runways were built on several British ships in 1916.

Great Britain's *Argus* was the first ship with a through-deck that allowed planes to both take off and land. It served as a model for aircraft carriers built later.

Since World War II, carriers have been grouped by structure and capabilities. All carriers in the U.S. fleet are attack class, meaning they can be converted for use in submarine warfare, utility, and assault helicopter functions.

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What is the black box in an airplane used for?

BY AIR AND BY SEA

1. Recording the conditions of an airplane's flight
2. Measuring a plane's speed on takeoff
3. Stowing flight manuals

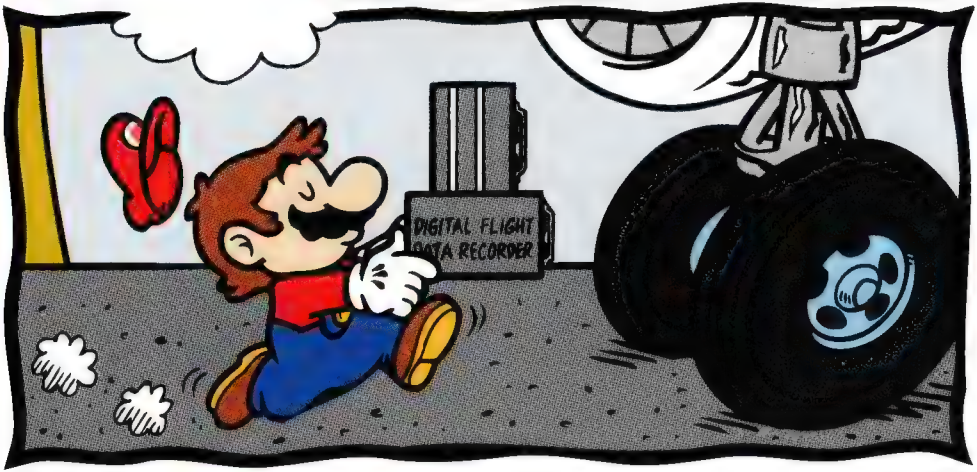

Illustration: Gary Fields

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Black Box

The black box, or flight recorder, of a plane is encased in a thick layer of metal and other insulating materials. This housing protects the flight recorder from being destroyed.

1 **The black box in an airplane records a plane's flight conditions and performance.**

© Len Sirman

After a crash, a plane's black box may be difficult to find. Pieces of it may be strewn over several miles or hidden under piles of rubble.

Black boxes are designed to withstand extremes in temperature and the severe shock of accidental landing. The insulating materials that protect a black box can withstand fires up to 2,000ºF (1,093ºC). The recording tape inside is protected from being erased and destroyed by water.

Information Recorded

Black boxes record airspeed, vertical acceleration, altitude, and aircraft pitch—the angle at which an airplane flies. A separate device records people talking inside the plane's cockpit and communication by radio. The black box and the device for recording voice transmissions are carried in the tail of the plane.

An airplane's black box is an important source of clues in the case of a crash or other unusual event. By analyzing the information recorded by a black box, it may be possible to determine the cause of a plane crash.

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When are the oxygen masks in airplanes used?

BY AIR AND BY SEA

1. When there is a loss of pressurization
2. When a passenger has an asthma attack
3. When the plane flies through polluted areas

Illustration, Gary Fields

©1996 Nintendo

Pressurization

Your body is used to a certain level of air pressure. Humans can survive at altitudes up to about 15,000 feet (4,575 m). Higher than that, air must be put under pressure artificially to sustain human life.

Air pressure and temperature decrease with altitude, or height above the ground. The air inside an airplane in flight is maintained at roughly the same pressure as the air on the ground. Air inside the plane's cabin is also kept at a constant temperature.

Commercial airplanes must meet certain regulations for oxygen supply and cabin pressure.

1 **Oxygen masks are used when there is a loss of pressurization inside the airplane.**

© Lunier / Jerrican

In modern commercial airplanes, each seat is equipped with a fold-down table, individually controlled reading lamps, and small fans to direct air flow. In case of emergency, an oxygen mask drops down from the overhead panel.

Safety Measures

Before takeoff, flight attendants show passengers what to do in case of a drop in internal pressure due, for example, to equipment malfunction. When depressurization occurs during a flight, oxygen masks are lowered automatically from panels on the ceiling above each seat. Passengers can use them to breathe normally until pressure is restored.

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What do airports use to ensure security?

BY AIR AND BY SEA

1. Scanners, microscopes, and mirrors
2. X-ray machines, metal detectors, and trained dogs
3. Guide dogs, calculators, and scales

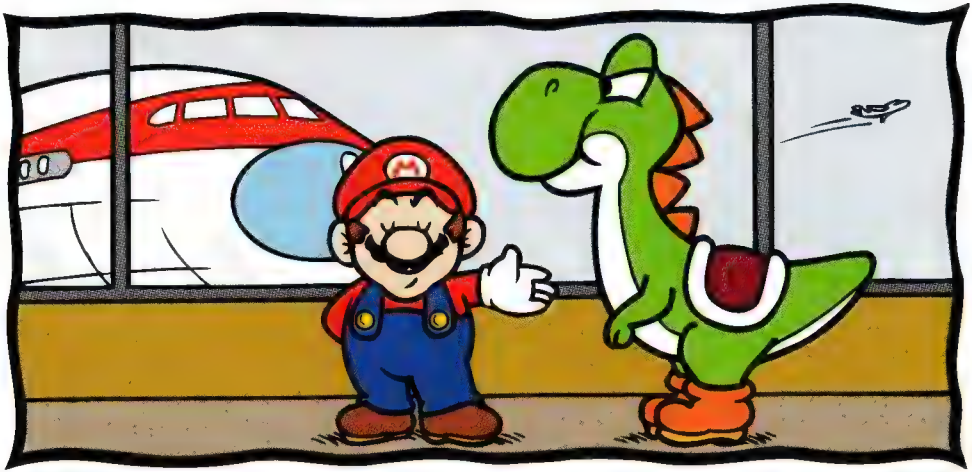

Illustration: Gary Fields

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Airport Security

If you travel by plane, you must put your carry-on luggage through an x-ray machine and walk through a metal detector before boarding the plane. Airports rely on these machines to help them find dangerous weapons and other objects that are not allowed on planes.

2 Airports use x-ray machines, metal detectors, and trained dogs to ensure security.

© Gordons / Jerrican

Magnetic detectors used to check passengers prior to flights sound an alarm when they sense a significant amount of metal.

The first paved runways in the U.S. were built at Newark, New Jersey, in 1928. Civilian air travel increased sharply after World War II.

Security Checks

Today, airports use a variety of methods to protect passenger security and prevent crime. Before boarding a plane, a person's ticket is checked against a form of personal identification, such as a passport or driver's license. Carry-on baggage is passed through x-ray machines, and passengers are requested to open any bags containing unidentifiable or potentially dangerous objects. Trained dogs may be used to sniff luggage for drugs and agricultural products.

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What are the three main types of airports?

BY AIR AND BY SEA

1. Private, public, and passenger
2. Government, public and private, and commercial
3. Military, civilian, and national

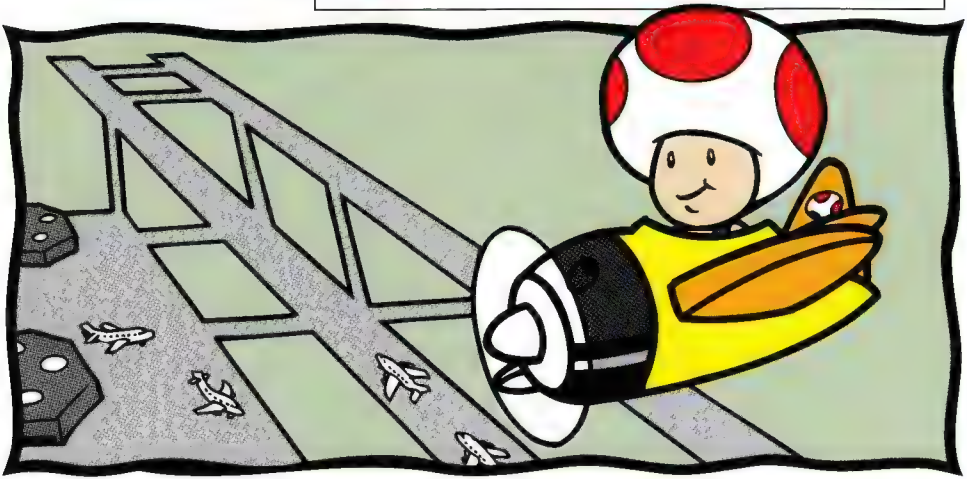

Illustration Gary Fields

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Airport

Government airports are primarily for the military. Public and private airports are used for recreational flying, flight instruction, and business. Commercial airports provide the services of foreign and domestic airlines to the public.

2 **The three main types of airports are government airports, public and private airports, and commercial airports.**

© S. Frances / Explorer

At most commercial airports, there are places for people to make flight reservations, purchase tickets, and exchange unused tickets. Airport ticketing agents use computers to determine whether flights have space available.

Airports consist of many different elements, including hangars—huge garages for planes—cargo-loading areas, parking ramps, control towers, and runways. When planning an airport, designers must consider the types of airplanes that will use the airport. Wide-bodied jets, for instance, need thick concrete runways at least 200 feet (60 m) wide and 14,000 feet (4,427 m) long.

Airplane terminals and runways are arranged according to the pattern of prevailing winds, since aircraft must always land and take off into the wind. With planes constantly landing and taking off, airports are noisy places. Because of this, another determining factor in airport location is the proximity of residential areas that may be bothered by the noise.

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What is one of the busiest airports in the United States?

BY AIR AND BY SEA

1. John F. Kennedy International Airport
2. Newark International Airport
3. Jacksonville Airport

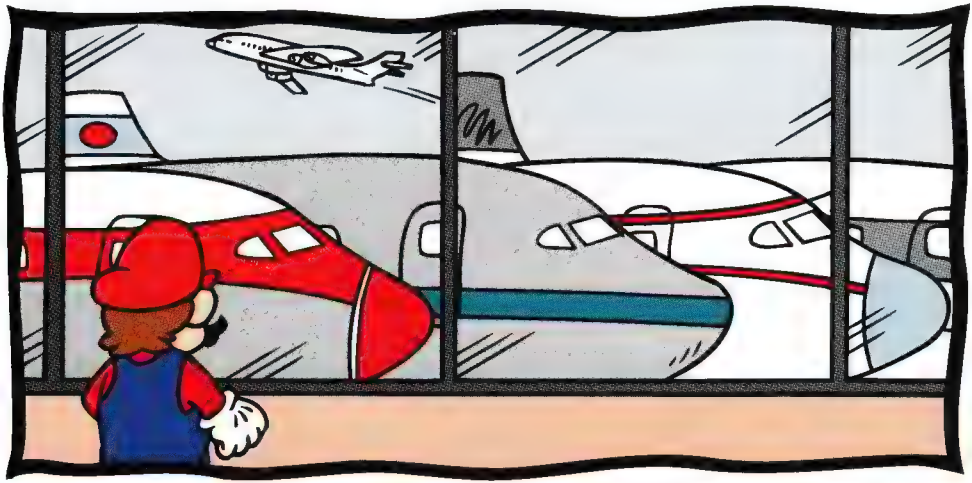

Illustration: Gary Fields

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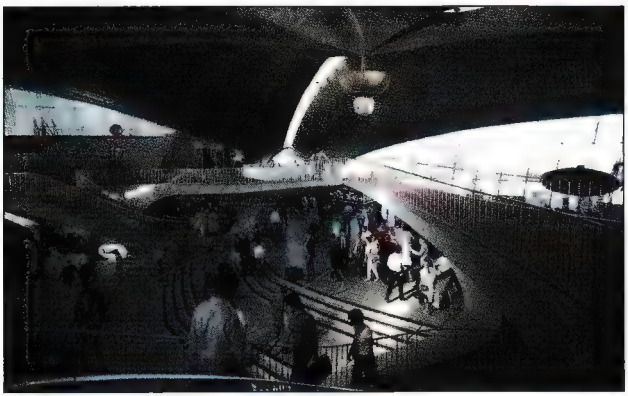
U.S. Airports

There are about 5,100 public and 12,400 private airports in the country. Commercial airlines in the United States serve more than 460 million passengers each year. The majority of these passengers are domestic travelers.

1 John F. Kennedy International Airport, in New York City, is one of the busiest public airports in the United States.



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Busy travellers pass through the TWA terminal at Kennedy Airport.

As air travel increased after World War II, people began to see airports as symbols of international prestige. Famous architects were sometimes hired to design airport terminal buildings. One such example is the Trans World Airlines (TWA) terminal at New York City's Kennedy Airport, designed by Finnish architect Eero Saarinen. Winglike roof sections made of concrete and glass cover the waiting areas.

Modern Conveniences

Today, major airports provide a wide array of services for travelers. There are restaurants, shops, barbershops, post offices, and banks. Passengers can rent cars or connect with taxis or buses. Many airports have links to train services. International airport terminals offer customs and currency-exchange services.

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How are icy areas cleared for ships?

BY AIR AND BY SEA

1. Workers break the ice with large picks.
2. Large heaters melt the ice.
3. Specialized ships break up the ice.

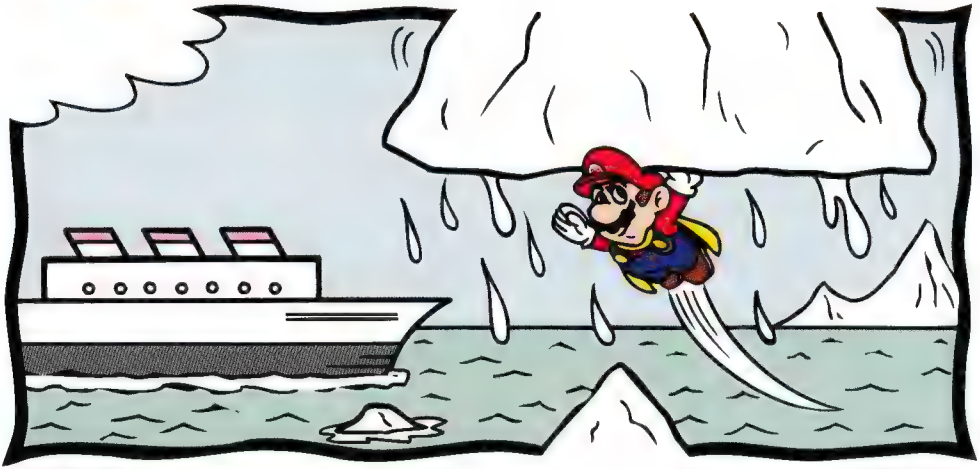

Illustration: Gary Fields

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Icebreaker

Icebreakers were introduced at the end of the 19th century. Before icebreakers were invented, ships could not cross frozen areas of ocean.

3 **Ships called icebreakers pass through icy areas to clear passages for ships.**

© Len Sirman

Today, Russia, Japan, the United States, Argentina, and Canada operate icebreakers capable of clearing passages through thick ice.

The first icebreakers were used on Russia's Lake Baikal and on the Baltic Sea. One of the most successful early icebreakers was the Russian-built *Ermak,* used on England's River Tyne beginning in 1898. It had a steel hull and reinforced bow that sloped gradually upward from the boat's base. It could glide up onto icy surfaces and shatter them with its weight. Most modern icebreakers have the same type of bow construction. Some are equipped with a bubbler system that circulates air between the hull and the ice to reduce friction.

Leaders in Technology

The former Soviet Union once led the world in icebreaker technology. It had a fleet of over 50 icebreakers and tugs in service.

Today, many of the world's icebreakers are designed in Finland. One example is Australia's ultra-modern *Aurora Australis,* used in Antarctic research expeditions.

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How does a pilot control a plane's rudder?

BY AIR AND BY SEA

1. With his feet
2. With his hands
3. With his mind

Illustration: Gary Fields

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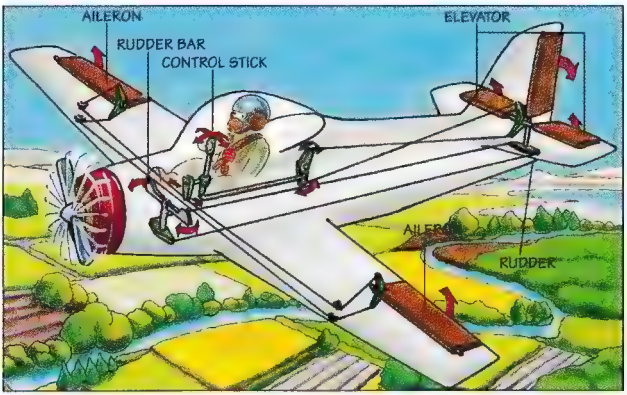
Flight Controls

An airplane's flight controls allow the pilot to steer the plane, and to raise or lower its nose.

1 **A pilot uses his feet to control the plane's rudder.**



© Y. Tabariés

Cables connect the rudder and elevator in the tail and ailerons in the wings to the flight controls in the cockpit of a plane.

The rudder is a vertical flap hinged to the airplane's tail. It is used to change a plane's direction. Cables connect the rudder to two foot pedals or a rudder bar on the floor of the cockpit at the front of the plane. When the pilot presses one pedal or one side of the bar the rudder shifts right or left. This changes the force of the air on the tail which causes the nose of the plane to turn.

The Control Stick

The pilot uses his hands to work the control stick, which is connected by cables to horizontal flaps, called the elevator, in the tail, and to horizontal flaps, called ailerons, in the wings. Pushing the stick forward adjusts the elevator so the tail of the plane rises and the nose lowers. Pulling back lowers the tail and raises the nose. Pushing right raises the right aileron and lowers the left, which causes the plane to bank to the right. Pushing left makes the plane bank left.

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In which part of the plane do passengers sit?

BY AIR AND BY SEA

1. Aileron
2. Fuselage
3. Landing gear

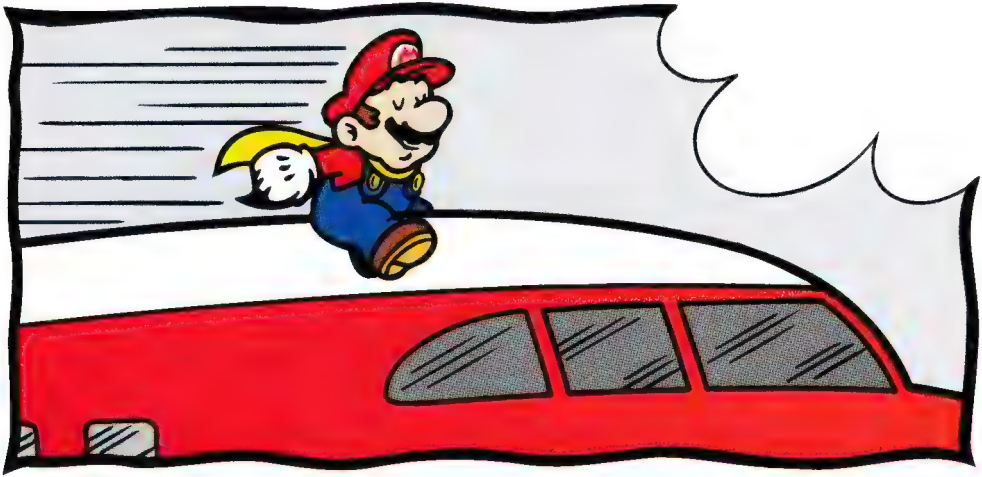

Illustration: Gary Fields

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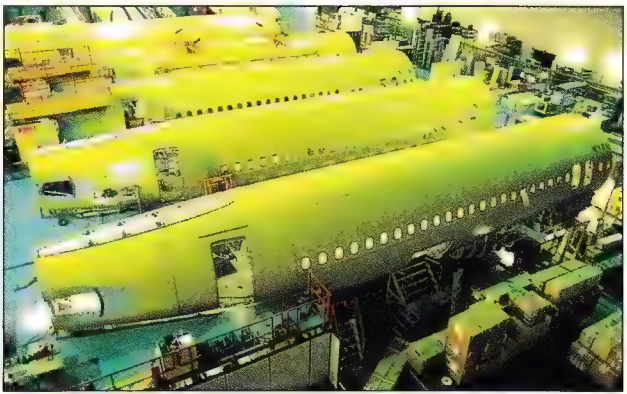
Fuselage

In early airplanes, pilots and passengers sat in open-air seats. Modern planes fly at altitudes too high for human comfort, so an enclosed fuselage is necessary.

2 Passengers sit in the cabin in the fuselage of an airplane.



© Riepholt / Spa Press

An airplane is built in pieces which are then assembled into a complete aircraft. Once this fuselage is finished, wings, a tail and a nose will be attached.

At high altitudes temperatures and air pressure are so low that humans couldn't survive them for long. The enclosed passenger cabin in the fuselage of an airplane protects passengers from bad weather and is climate-controlled so the air remains at a comfortable temperature. The cabin's ventilation system provides oxygen for passengers.

Construction

There are two types of aircraft fuselage. A truss fuselage, used in small planes, is made up of a series of metal tubes fused into triangular trusses. These bear the weight of air pressure and other stresses that affect a plane in flight. A metal or fiber glass "skin" is stretched over this framework to enclose the fuselage. Commercial jets usually have a stressed-skin fuselage. In this case, the reinforced metal skin of the fuselage bears the stress.

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What is a Messerschmitt?

BY AIR AND BY SEA

1. An Austrian gun
2. German World War II aircraft
3. Swiss beer

Illustration: Gary Fields

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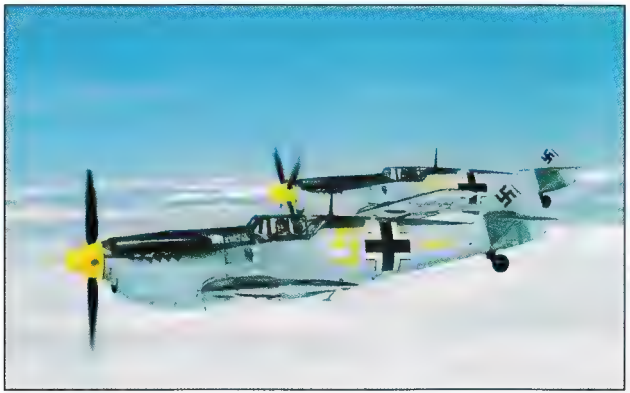
Messerschmitt

Willy Messerschmitt was a German aircraft engineer. The planes he designed were used by the Nazi airforce, or Luftwaffe, during World War II.

2 Messerschmitt aircraft were used by the German army during World War II.



© Artistes Associed D. James / Sipa Icono

These are Messerschmitt aircraft, flown by the Nazi airforce, or Luftwaffe, during World War II, shortly before Germany surrendered in 1944.

During World War I, military aircraft were used mainly for aerial surveillance. In World War II, planes were equipped with machine guns and bomb bays so that they could be used in combat.

Enemy Aircraft

Combat planes had to be small, fast, and easy to maneuver. Willy Messerschmitt (1898-1978) became famous for the planes he designed for the Nazi regime. He is best known for the BF-109, an all-metal, single-seat fighter plane which was made by the German aircraft company Bayerische Flugzeugwerke (the BF in the plane's name refers to the manufacturer). Several years later, the company was renamed Messerschmitt-Aktien-Gesellschaft, and the plane became known as the ME-109 (ME for Messerschmitt). About 35,000 ME-109s were built for the Nazis in World War II.

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What is the ensign on a ship?

BY AIR AND BY SEA

1. A flag that designates its national origin
2. The cabin where the captain sleeps
3. The ship's kitchen

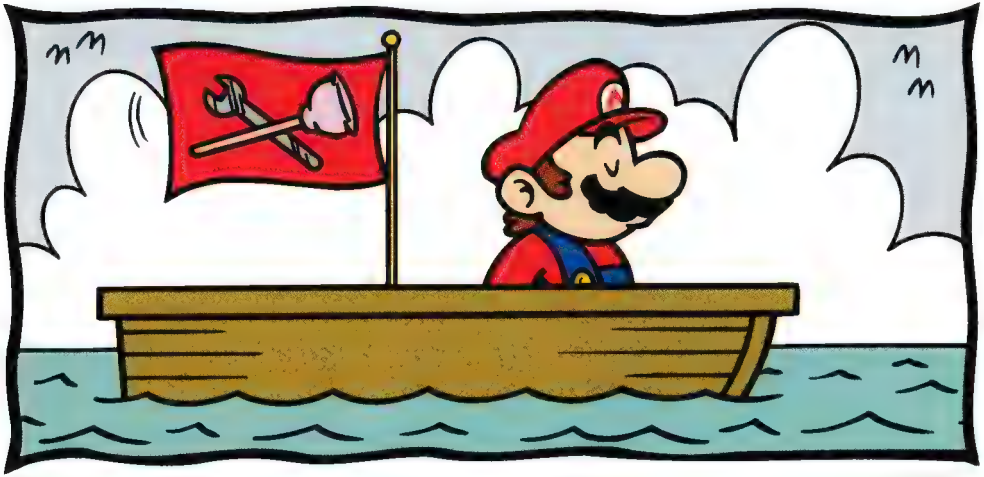

Illustration Gary Fields

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Ensigns

Ships and pleasure boats carry ensigns, or national flags, that indicate the country in which they are registered.

1 An ensign is a ship's national flag.

© Len Sirman

This German ship is flying a German war ensign. The war ensign is similar to the black, red, and gold striped German flag, but its ends are cut on the diagonal in a swallowtail shape and the center bears the state coat of arms—a black eagle on a yellow shield.

Just like cars, boats must be registered with the government before they can be put to sea. To indicate the country in which they are registered, boats display a national flag, called an ensign. Most pleasure boats use an ordinary national flag as their ensign. Boats affiliated with a particular yacht club might fly the club's ensign as well. Merchant ships—commercial vessels used to carry cargo—also fly an ordinary national flag. Naval warships might fly war ensigns, which usually vary slightly from the national flag in shape or insignia. In some countries, a war ensign is used to distinguish a ship carrying weapons from one that is unarmed.

Dipping the Ensign

When ships from different countries pass each other at sea, they dip the ensign. They lower the flag about one-third down the flagpole and then raise it again as a sort of nautical salute.

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What word is used to indicate the left side of a ship?

BY AIR AND BY SEA

1. Port
2. Starboard
3. Stern

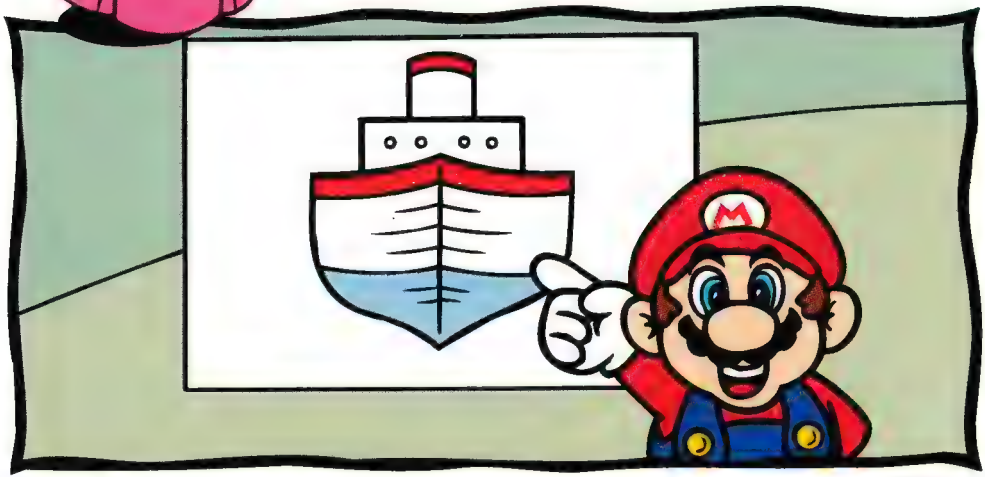

Illustration: Gary Fields

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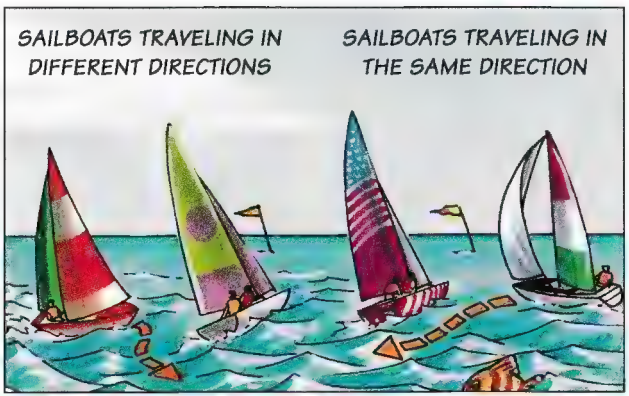
Nautical Terms

As you're facing forward on a boat, the left side is called port, and the right side is called starboard. You can remember port is left by remembering that both words have four letters.

1 Port is the nautical term used to designate the left side of a ship.



In sailing, "right of way" depends on whether a boat is on port or starboard tack, that is whether the wind comes from the right or left side. For boats traveling in opposite directions, the boat on starboard tack has right of way. When they're traveling in the same direction, the leeward, or downwind boat has right of way.

The word starboard comes from old-fashioned ships that had a huge oar, or steering board, on their right sides. The right side became known as the steerboard, or starboard, side.

Why Port?

No one is sure why the left side is called "port," however. Traditionally, cargo and passengers were loaded onto ships on the left side. It was easier to load from the left since the steering oar was projecting from the ship's right side.

The process of loading a ship with cargo is called lading. So, the left side of the ship was known as the ladeboard, or larboard side. But larboard and starboard sounded too much alike. In 1844, the nautical term for the left side of a vessel was officially changed to "port" to avoid confusion.

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Why do ships have figureheads?

BY AIR AND BY SEA

1. They hold the ship together
2. To give sailors something pretty to look at
3. They developed from early religion and superstition

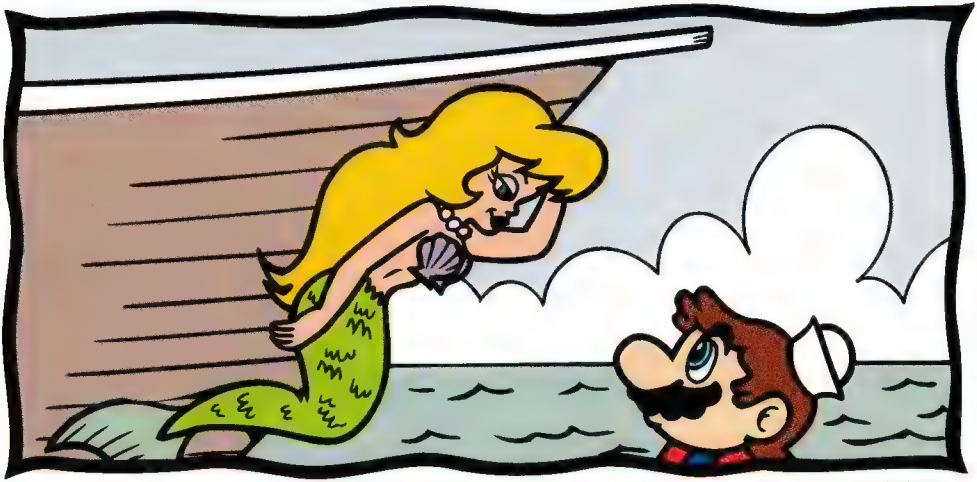

Illustration: Gary Fields

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Ship Figureheads

A figurehead is a carving mounted on the prow, or front, of a ship.

3 Ship figureheads developed from early religion and superstition.

© J.-Ch. Pratt / D Pries / Dhaf

Ancient sailors believed a figurehead could protect their ship from harm and help it stay on course. Modern sailors probably don't believe those superstitions...but some decorate their ships with figureheads just the same!

Ancient sailors knew how dangerous life at sea could be. When they traveled they wanted to be protected by their gods. Some historians believe this is why ancient sailors carved huge characters or figureheads on the prows of their ships. Early figureheads were religious symbols—like the holy birds of ancient Egypt.

The Ship Has Eyes

Ancient and medieval sailors also believed that a ship was a living being. To travel on course a ship needed eyes. The figurehead provided these eyes. Medieval figureheads represented fierce or fast animals, like lions and horses. Viking ships were known for their ferocious dragon figureheads.

Later Symbols

Seventeenth-century figureheads were elaborate. English ships of the time had figureheads of kings on horseback and St. George slaying the dragon. This began a trend of figureheads that represented the name of the ship.

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What award was given to the fastest transatlantic ocean liner?

BY AIR AND BY SEA

1. The Blue Riband
2. The Golden Rudder
3. The Silver Compass

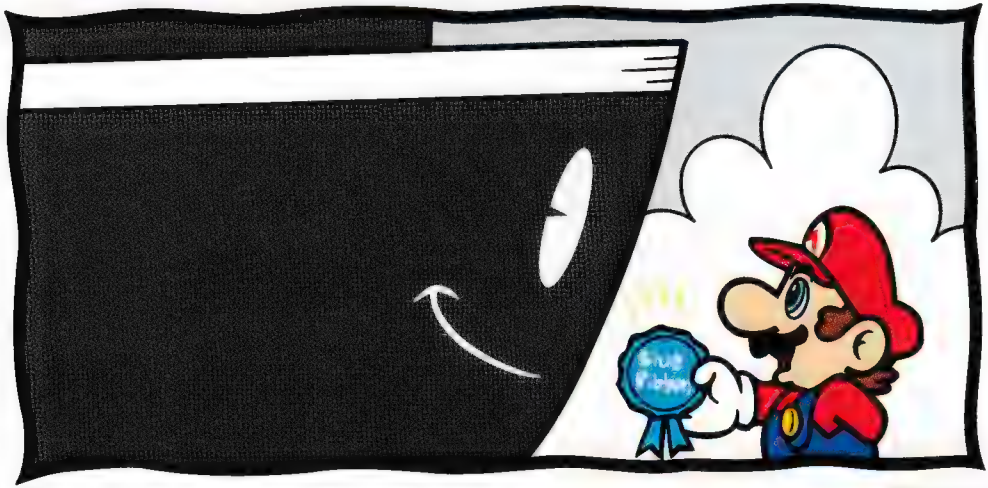

Illustration: Gary Fields

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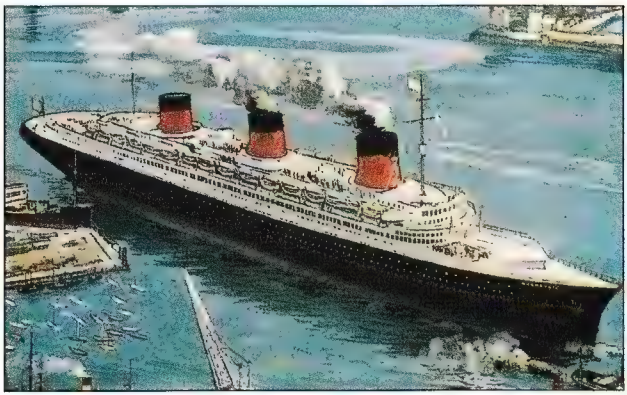
Blue Riband

Captains and crews of passenger ships traveling between the U.S. and Europe had an ongoing competition to see who could make the crossing in the fastest time.

The Blue Riband was an honorary award given to the fastest transatlantic liner.



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The French ship *Normandie* won the Blue Riband in 1937. The current prize-holder is the American ship *United States*, which was retired from service in 1970.

Today it's rare for passenger boats to travel between the U.S. and Europe, but before air travel became widely available the only way to make the trip was by boat. The trip took days, but passengers on luxury liners didn't mind. They relaxed, socialized, and enjoyed the voyage.

Friendly Competition

Companies that operated transatlantic liners always tried to outdo each other by building bigger, faster ships. At the turn of the century, an unofficial competition began to see who could cross the Atlantic Ocean in the fastest time. The prize was the Blue Riband (or ribbon) of the Atlantic. First to win was the British ship *Acadia* in 1840. The last ship to hold it was the S/S *United States,* which won in 1952. It crossed the Atlantic in 3 days, 10 hours, and 40 minutes—a record that has never been broken.

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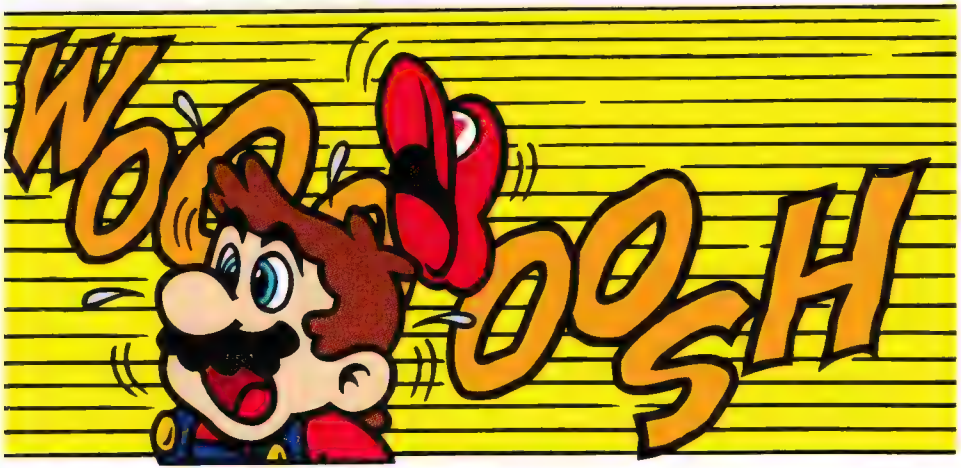
What is supersonic transport?

BY AIR AND BY SEA

1. A large cargo plane
2. A plane that flies faster than the speed of sound
3. A brand of Japanese aircraft



Illustration, Gary Fields

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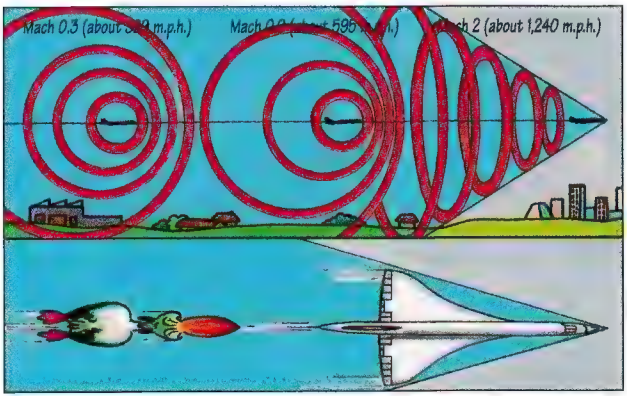
Supersonic Transport

Sound travels through air at about 760 miles per hour (1,225 km/h). A supersonic aircraft travels even faster.

2 Supersonic transport flies faster than the speed of sound.



© Y. Tabarres

Today's supersonic transport, or SSTs, fly at Mach 2 or even faster. That's twice the speed of sound!

The speed of an airplane is often judged in terms of the speed that sound travels through air. An aircraft that travels faster than the speed of sound is called supersonic, or "above sound." These planes, such as the Concorde commercial airplanes, are known as SSTs or supersonic transport.

"Mach-ing" Time

Ernst Mach, a German physicist, developed the method of calculating the speed of an object in terms of the speed of sound. The ratio of the object's speed to the speed of sound is called a Mach number in his honor. Planes that travel at exactly the speed of sound are said to travel at Mach 1. The faster a plane travels, the higher its Mach number.

The Right Stuff

The first pilot to fly an aircraft at Mach 1 was U.S. Air Force Major Charles E. "Chuck" Yeager. He reached Mach 1.45 on a test flight in 1947. Yeager was the first pilot to break the sound barrier.

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What are blimps used for?

BY AIR AND BY SEA

1. Advertising
2. Surveillance
3. Both

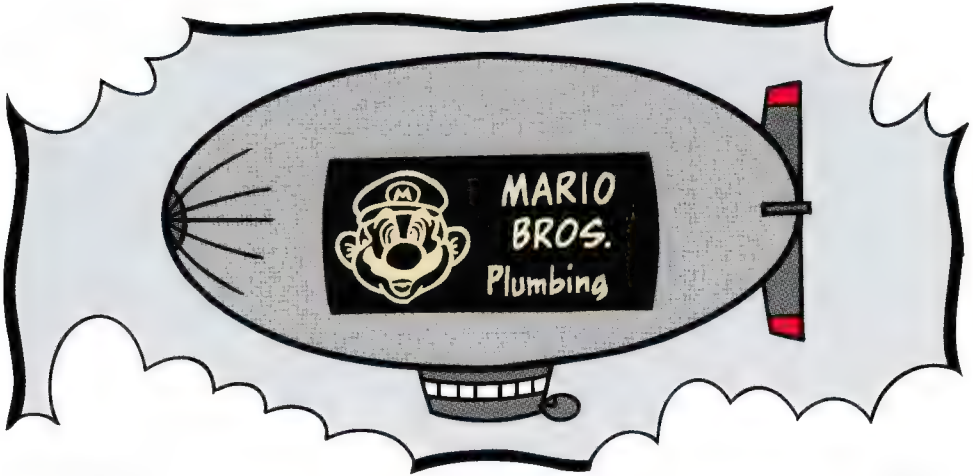

Illustration Gary Fields

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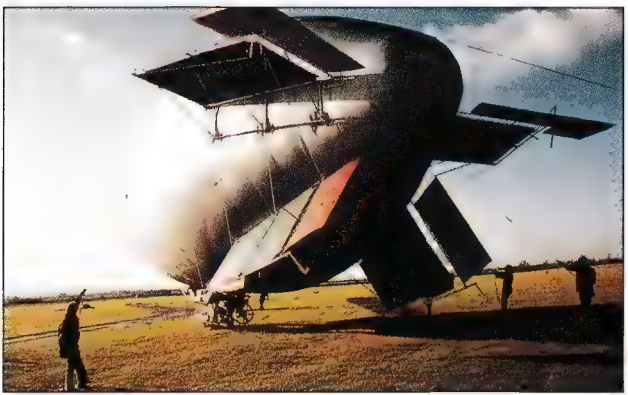
Blimps

A blimp is a non-rigid, lighter-than-air airship. The first blimp was powered by a steam engine. It was built in 1852.

3 Blimps are used for both advertising and surveillance.



© Len Sirman

A blimp is a non-rigid aircraft that is inflated with gas—usually hydrogen or helium—to give it its shape and to make it float.

The difference between blimps and zeppelins is the way they are constructed. Zeppelins are rigid airships built around a frame that holds their shape. Blimps are non-rigid. Their outer shells are made of rubberized fabric which is inflated like a balloon to give the airship its shape.

Flight Time

Blimps were used for military aerial surveillance during World War I and World War II. Even though they don't fly as fast as airplanes, blimps were useful for surveillance because they can stay aloft far longer than most airplanes. The U.S. Navy continued to use blimps for surveillance until 1962.

Eye in the Sky

Today blimps are used mainly for advertising during parades and sporting events. Blimps from Goodyear, MetLife, and Fuji Film, hover above the events taking aerial photos and advertising their sponsors' products.

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What were clipper ships known for?

BY AIR AND BY SEA

1. Huge hulls
2. Speed
3. Electronic navigational equipment

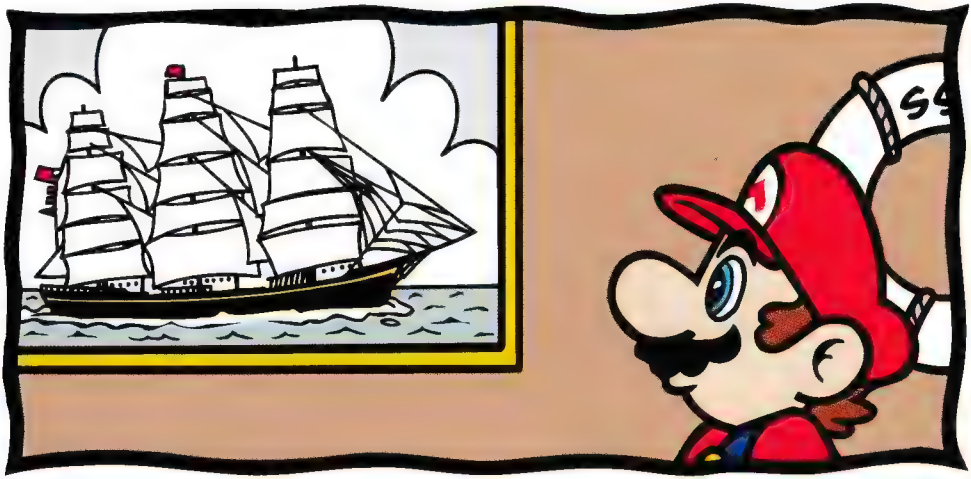

Illustration Gary Fields

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Clippers

The first true clippers were built in the United States around 1845. Soon after, English ship-builders adopted the style for their trading ships.

2 In their day, clippers were known as the fastest sailing ships.

© Coll ES / Explorer Archives

Clipper ships of the 1800s were known for their speed and for their graceful, streamlined shape.

In the 19th century, clippers were the fastest way to travel by sea. People who wanted to travel quickly from the east coast to California went by clipper. They had a good reason to hurry. By 1848 gold had been discovered in California and prospectors were eager to head west.

In England, speedy clippers were used by trading companies to transport tea from China. The first tea of the season was always in heavy demand, and the company that delivered its shipment earliest stood to make the most money.

Built for Speed

Clippers were long, narrow three-masted schooners with very long pointed bows or fronts. They were able to sail faster than other ships because the sails were quite large in relation to the hull and little of the hull was in contact with the water, causing less drag or resistance.

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Who is credited with inventing the steamboat?

BY AIR AND BY SEA

1. American inventor Robert Fulton
2. French chemist Louis Pasteur
3. English admiral Horatio Nelson

Illustration Gary Fields

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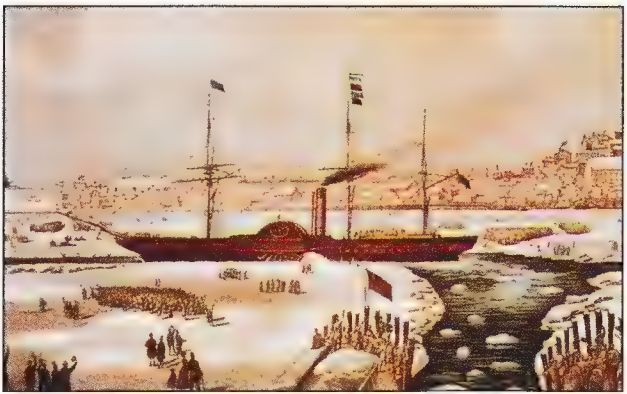
Steamboat

The steamboat wouldn't have been possible without the steam engine, created by Scottish inventor James Watt.

1 American inventor Robert Fulton is credited with inventing the steamboat.



© ERL / Sipa-Icono

In the 1800s, paddle steamers ferried passengers on the Hudson River between New York City and Albany. Later, they were used on the Mississippi and Missouri Rivers, too.

Fulton incorporated Watt's patented engine into his boat design. He added a paddle wheel to propel the boat through the water. In time, the boats became known as paddle steamers because of their distinctive, and sometimes beautifully decorated, paddle wheels.

Experiments and Success

In 1803, Fulton conducted his first steamboat runs on the Seine River in Paris. The boats traveled at about 3 miles per hour. People walk faster than that! He returned to the U.S. to try again. In 1807, he had another boat ready. With partner Robert Livingston, Fulton launched his new steamboat on the Hudson River in New York. The boat became known as the *Clermont,* named for Livingston's estate. It chugged along at 5 miles per hour—a success for all concerned. It wasn't long before passenger ferry service was started on the Hudson River between New York City and Albany.

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When did modern ocean liners come into use?

BY AIR AND BY SEA

1. 1900s
2. 1950s
3. 1980s

Illustration, Gary Fields

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Ocean Liners

In its time, cruising on an ocean liner was the fastest, most luxurious way to travel.

1 Large passenger ships, called ocean liners, came into use in the 1900s.

© Len Sirman

Great ocean liners, like the *Queen Elizabeth II* and the *France,* are no longer in use. Modern cruise ships are the closest thing we have to the luxurious transatlantic liners of the past.

Ocean liners were built according to the principle that the bigger a boat is, the less power it takes to drive it. Liners could travel faster than small boats on the same amount of fuel.

The Bigger the Better

The first liner, called the *Great Eastern,* was so big it couldn't get out of port! When it was launched, in the 1850s, it got stuck. It was so large—690 feet (210 m) long—there was no towing or hoisting equipment that could handle it.

Sea Cruise

By 1899, when the *Oceanic* was launched, ports were prepared for the big boats and the age of the liner was born. Liners kept growing. By World War II a typical ocean liner was more than 900 feet (272 m) long and carried about 2,000 passengers. Ocean liners were the primary to travel between continents. After World War II, air travel became available and the golden age of ocean liners ended.

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How do pilots that speak different languages talk to each other?

BY AIR AND BY SEA

1. Hand signals
2. International Phonetic Alphabet
3. Braille

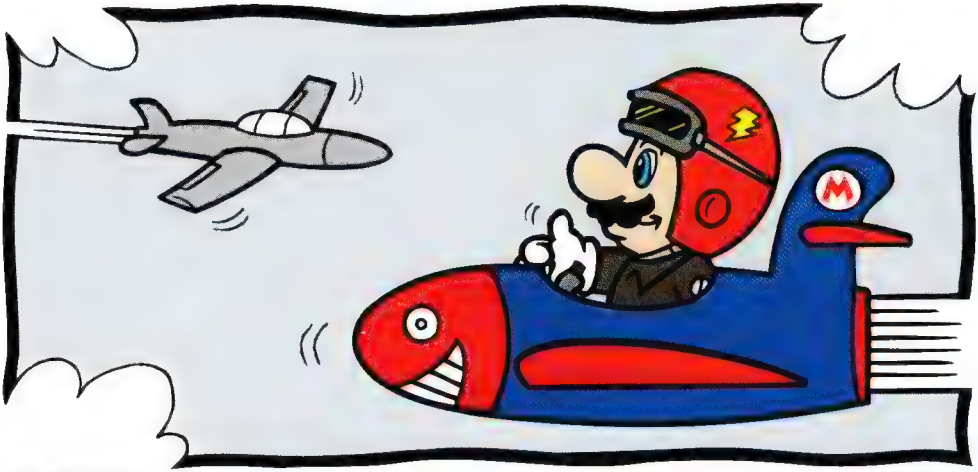

Illustration: Gary Fields

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Phonetic Alphabet

When information can't be communicated clearly over a radio, pilots and air traffic controllers may "spell it out" using the international phonetic alphabet.

2 Pilots communicate using the international phonetic alphabet.

© S. Frances / Explorer

Learning the international phonetic alphabet is part of every pilot's training. Pilots must be able to communicate with air traffic controllers and other pilots all over the world.

When pilots approach an airport, they open radio communication with the control tower. But if they don't speak the same language, or if there's static on the airwaves, it's hard for them to communicate. That's when they may use the international phonetic alphabet to spell out standard codes.

Sounds Like...

Because many letters sound alike, the alphabet uses a word to represent each letter. A=Alpha. B=Bravo. C=Charlie. D=Delta. And so on. If planes BF123 and TX123 were approaching the tower at the same time, their identification numbers might sound alike to the controller. But if they identify themselves as "Bravo Foxtrot 123" and "Tango X-ray 123" there won't be any confusion. To avoid confusion between the sounds of the numbers five and nine, pilots often use "niner" for nine.

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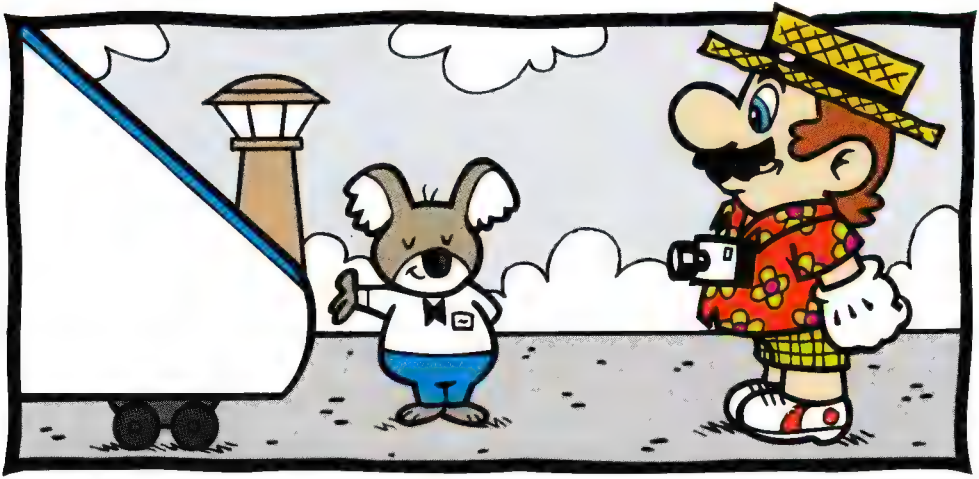
Which is the national airline of Australia?

BY AIR AND BY SEA

1. Iberia
2. KLM
3. Qantas



Illustration, Gary Fields

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Airlines

There are no government-owned commercial airlines in the U.S., but many countries have airlines that are owned wholly or in part by their governments.

3 Australia's national airline is Qantas.

© Fourmy / REA

Royal Jordanian Airlines is the government-owned airline of Jordan. Many countries have airlines that are operated by their national governments.

Qantas, the unusual name of Australia's national airline, stands for Queensland and Northern Territory Aerial Services. Iberia is the national airline of Spain, and KLM is the Royal Dutch Airline.

Passenger Flights

Airplanes didn't really start carrying passengers until after World War I. The planes were noisy and uncomfortable military aircraft that had been fitted with passenger seats.

Air Mail

The first transcontinental air service between New York and California began in 1930. Still, most people preferred to travel by ground transportation. To help airlines stay in business, the U.S. government awarded them contracts to carry mail from point to point. In the early days, commercial planes carried more mail than passengers. Today, however, air travel has almost completely replaced train travel in the United States, and it has taken the place of ships for transatlantic journeys.

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What is an airplane's preparation for landing called?

BY AIR AND BY SEA

1. Approach
2. Takeoff
3. Throttle

Illustration: Gary Fields

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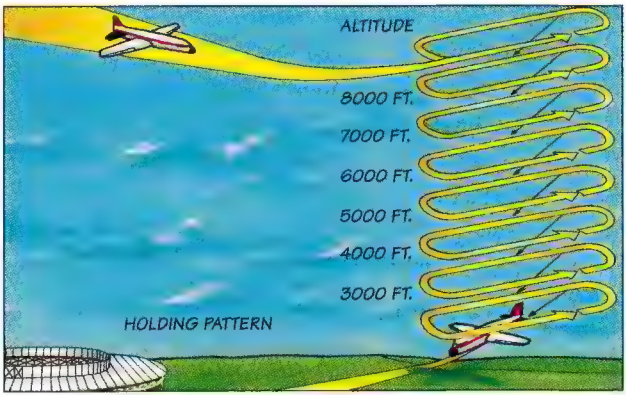
Approach

At the end of a flight, the pilot begins the plane's descent toward the runway. This descent is called the approach.

1 Before an airplane lands, it goes through the approach.



© Y Tabarés

At a crowded airport, airplanes wishing to land may be directed into a holding pattern. They circle above the airport waiting for their turn to land.

The air traffic controller in the airport control tower identifies the plane, confirms its altitude and gives it permission to land. The controller might also provide the pilot with information about wind speed and direction, and ground weather conditions. At large airports, approaches and landings are assisted by radar which helps guide the plane to a safe landing.

Flying in Circles

There are several reasons that airplanes might circle over an airport before landing. As an airplane approaches an airport, it enters the airport's traffic pattern. When the airport is very busy, the plane circles over the airport awaiting its turn to land. This circling is called a holding pattern.

If an airplane approaches the runway at an angle, it circles to align itself with the runway so it can land.

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Who was the first pilot to fly a loop-the-loop?

BY AIR AND BY SEA

1. Adolphe Pegoud
2. Wiley Post
3. Eddie Rickenbacker

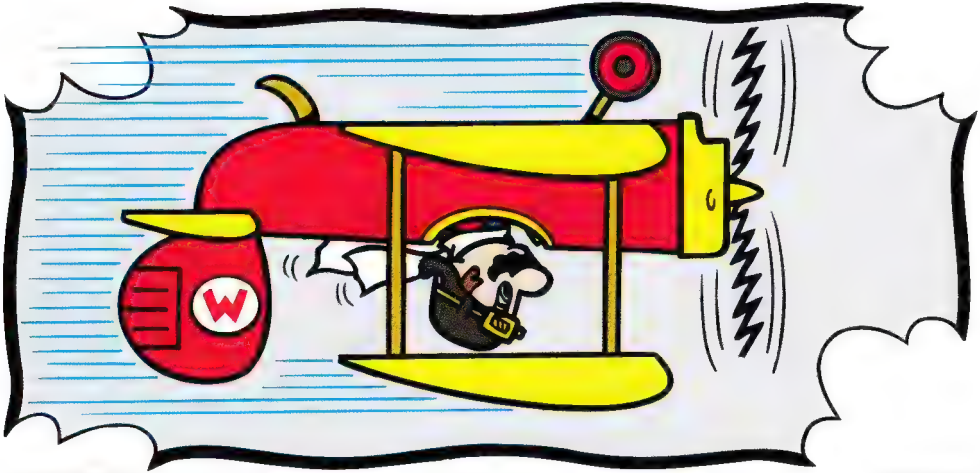

Illustration Gary Fields

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Stunt Flying

Early pilots, like Adolphe Pegoud, were daredevils. They loved testing the capabilities of newfangled aircraft, even though they often risked their lives to do it.

1 Adolphe Pegoud is considered the first pilot to fly a loop-the-loop.

© Len Sirman

The first loop-the-loop was performed in a biplane like this one.

Pegoud is credited as the first pilot to perfect the loop-the-loop maneuver, in which a plane flies straight up, then over backwards in a complete circle. He performed the feat for the first time in 1913. A loop is different from a roll maneuver, in which the plane rolls to its side while still moving forward.

Fighting and Fun

The maneuvers perfected by these early fliers became an important part of training for military pilots. World War I marked the first time that aircraft were used in combat. During aerial dogfights—battles between individual planes—pilots needed these tricky maneuvers to survive attacks and evade their enemies. After the war, demonstrations of stunt flying—called aerobatics—were done in traveling shows across the country. They were called barnstorming shows because they usually were performed in rural areas.

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What do a plane's swing wings do?

BY AIR AND BY SEA

1. Allow it to perform aerial stunts
2. Allow it to land on land or water
3. Increase fuel efficiency flying at different speeds

Illustration, Gary Fields

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Military Aircraft

Planes used in combat have a wide variety of technical capabilities that are not usually present in ordinary jet planes.

3 Swing wings help a plane fly more efficiently at different speeds.

© M. Raden / Explorer

Military aircraft are built for speed and efficiency. Fighters and attack aircraft can fly at twice the speed of sound and still make quick turns and strikes in aerial combat.

Swing wings, for example, are moved forward or back depending on the plane's speed. At low speeds, the wings are positioned forward. At supersonic speeds, they're moved back toward the tail to make the plane streamlined.

Maximum Efficiency

High-performance military planes are equipped with sophisticated, powerful engines and finely tuned controls that let pilots maneuver the planes quickly and easily. The F-14 Tomcat, used by the U.S. Navy, is built to fly at extremely fast speeds—sometimes twice the speed of sound. The plane's computer adjusts its wings for maximum efficiency. They fan out when the plane is cruising at low speed and tuck back against the fuselage when the plane flies at top speed. Most military aircraft are named by function. The F-14 is a fighter plane. The B-52 is a bomber. The A-6E is an attack plane.

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Can lightning strike airplanes in flight?

BY AIR AND BY SEA

1 Yes

2 No

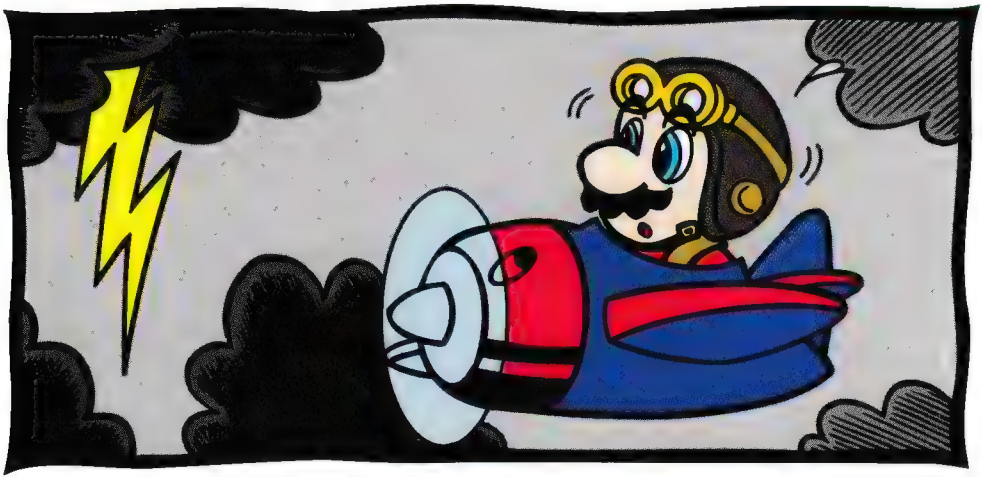

Illustration Gary Fields

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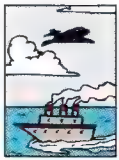
Lightning

Pilots try to avoid flying directly through thunderstorms. New weather information systems make it easier to avoid storms.

1 Yes, lightning occasionally strikes airplanes in flight.



© Y Tabaré

When lightning strikes a plane in flight it sends an electrical charge from one end of the plane to the other. It usually does not do severe damage to the plane.

When there are thunderstorms on a plane's flight path there are several ways pilots can avoid them. First, they can fly around the storm. Another choice is to fly below the storm. The plane will be hit with rain, but it will avoid the rough storm winds. The important thing is to avoid flying through the heart of the storm.

Advance Information

Planes are equipped with radar that detects storms in the flight path, but the radar has a limited range. A new information system developed by NASA helps pilots avoid severe weather by providing computerized storm maps to pilots right in the cockpit. While the plane is in flight, the pilot receives instant weather maps that indicate where storms are on the plane's current flight path, and which routes the pilot can take to avoid the storms.

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What is the Merchant Marine?

BY AIR AND BY SEA

1. A nation's cargo ships
2. An organization that sells boats
3. A club for retired naval officers

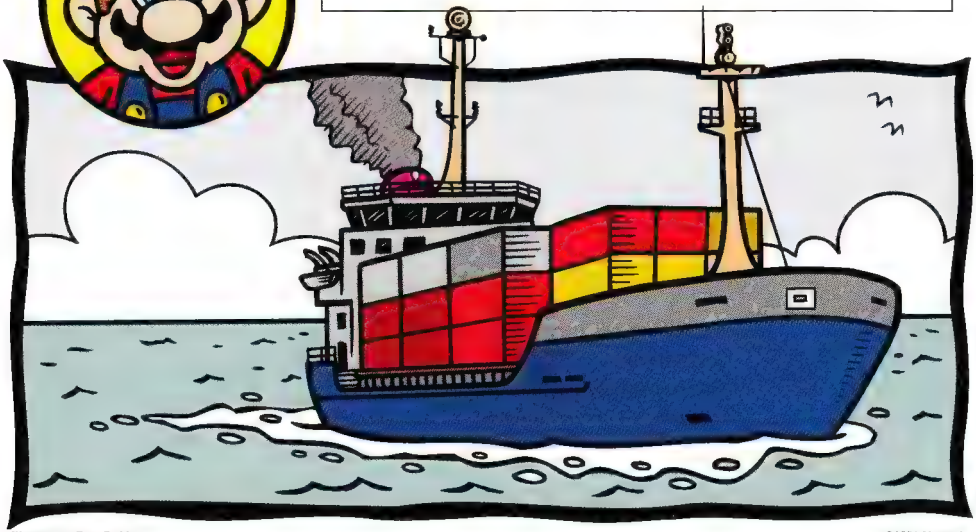

Illustration Gary Fields

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Merchant Marine

The United States Merchant Marine Academy is in Kings Point, New York. It educates and trains people to work on commercial cargo ships.

1 The Merchant Marine is the name given to a nation's cargo ships.

© Len Sirman

These rectangular containers will be loaded onto a special type of cargo-carrying ship called a container ship. Packing cargo in containers makes it easier for the ship to be loaded. Workers always know exactly how many containers a ship can hold.

Commercial shipping refers to boats that carry goods, or cargo, from one place to another. Cargo may include food, like a shipment of bananas from South America; raw materials, like steel or oil; or finished products, like cars and furniture. Though shipping cargo by boats can take a long time, it's less expensive than shipping heavy goods by air. In some parts of the world, cargo ships are the only means to transport goods from one place to another.

Modern Ships

Cargo ships are often designed for specific purposes. Those that carry general cargo are called container ships. The cargo is packed into large rectangular containers that can be loaded onto the ship and stacked evenly. Special refrigerated container ships carry agricultural products. Tankers are made to carry oil. Bulkers are specialized tankers that carry dry bulk cargo such as coal or grain.

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During which war were torpedoes first used?

BY AIR AND BY SEA

1. Civil War
2. Vietnam War
3. World War II

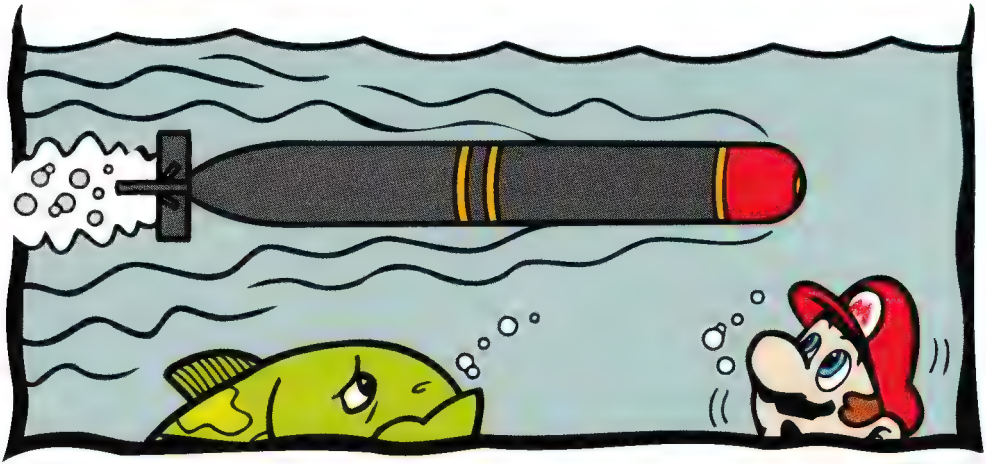

Illustration Gary Fields

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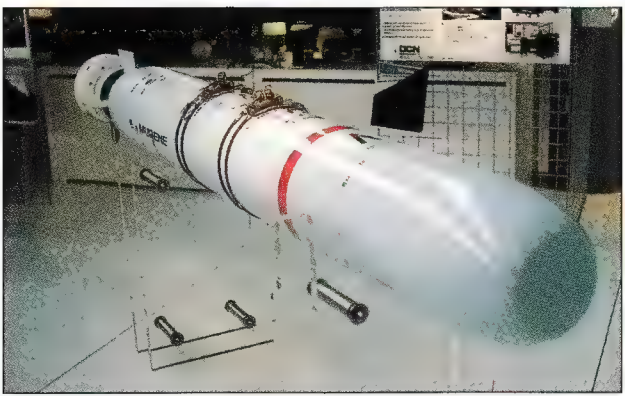
Torpedoes

The first torpedoes, used during the Civil War, were made from explosives attached to long poles. They were thrown at enemy ships by soldiers in small boats.

1 Torpedoes were first used in the Civil War.



© P. Habans / Sygma

The head of a torpedo contains an explosive charge, detonator, and guidance system. The tail contains a propeller and engine. The body of the torpedo contains fuel.

The modern torpedo is a cylinder-shaped underwater missile that carries an explosive charge at its head, and is powered by propellers in its tail. English engineer Robert Whitehead designed the first self-propelled torpedo in 1866.

Underwater Warfare

Since then, torpedoes have become more sophisticated. Many modern torpedoes contain their own guidance systems which help them identify and find their targets. Some torpedoes are guided by sonar. The torpedo generates a sound signal that travels through the water. When the signal hits the target it echoes back. The torpedo detects the echo and heads toward it. Other sound-guided torpedoes are designed to detect sounds emitted by their targets. Torpedoes may also be guided by controls in the ship or submarine from which they were launched.

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Which part of a ship supports the sails?

BY AIR AND BY SEA

1. Hull
2. Mast
3. Rudder

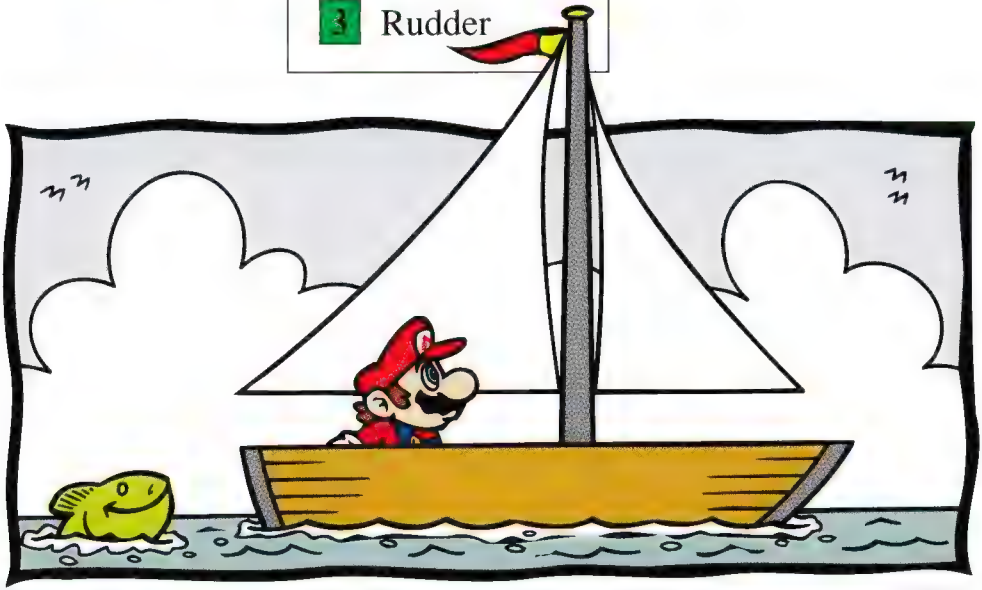

Illustration: Gary Fields

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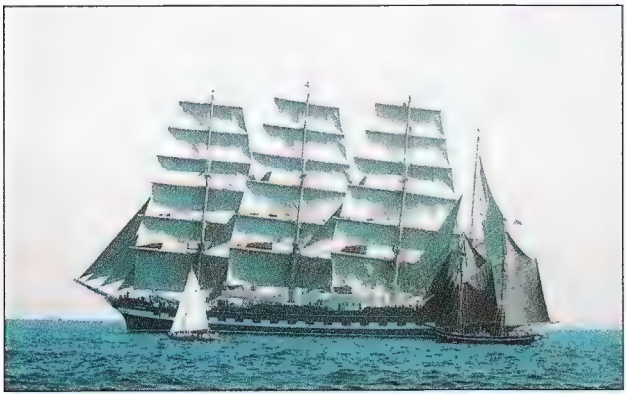
Mast

A mast is a vertical pole that holds the ropes and poles, or rigging, that support a ship's sails.

2 The mast supports a ship's sails.



© Len Sirman

Small sailing ships usually have one mast. Larger ships may have two or three.

Originally, masts were cut and shaped from the trunk of a single fir tree. They were tall and strong, but flexible so they wouldn't snap during a storm wind. However, some countries didn't have large forests that could be used for shipbuilding. Other nations used up their supply of suitable trees in a hurry.

Mast Transportation

When the local supply was used up, shipbuilders went far from home to find materials for masts. The hard part was transporting the trees back to their workshops. Some even tried building temporary boats from the tree trunks, then dismantling the boat on arrival and using the wood for masts. It didn't work.

Instead, special mast ships were built to carry trees. The ships were long, with specially designed cargo holds that allowed the trees to be slid inside.

Today, masts are made from fiberglass or other materials. Wooden masts are usually constructed from several pieces.

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What is a ship's draft?

BY AIR AND BY SEA

1. The amount of wind it takes to power it
2. The onboard heating and cooling system
3. The amount of water it takes to float it

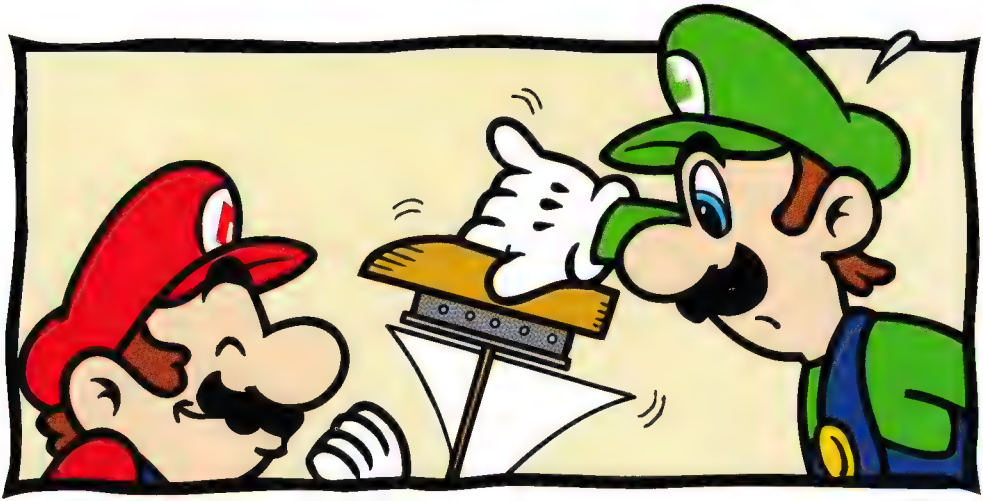

Illustration: Gary Fields

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Nautical Draft

The distance between the surface of the water and the lowest part of the boat underwater is called the draft.

3 A ship's draft is the amount of water it needs to float.

© L. Maquet

When a boat travels into areas where the water is too shallow to float it, the boat becomes stuck in the mud beneath the water. This is called running aground.

Flat-bottomed boats are good for use in shallow water because they have little draft. In other words, there is a small distance between the surface of the water and the lowest point on the boat. Flat-bottomed boats are also used for speed racing because they are able to skim across the water's surface. While this helps them travel fast, it also means they become caught in every ripple and wave, which can make for a bumpy ride.

Displacement

The body of a boat is called the hull. Boats made for deep water have pitched, or displacement, hulls. Their bottoms sit low in the water. This allows the boat to travel through the water by pushing the water out of the way, or displacing it. Boats with displacement hulls sometimes don't travel as fast as flat-bottomed boats, however they provide a steadier, smoother ride and they're more stable and safe in foul weather.

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What is an anchorage?

BY AIR AND BY SEA

1. Where a boat may safely drop anchor
2. Where the anchor is stored on a boat
3. A school for training naval officers

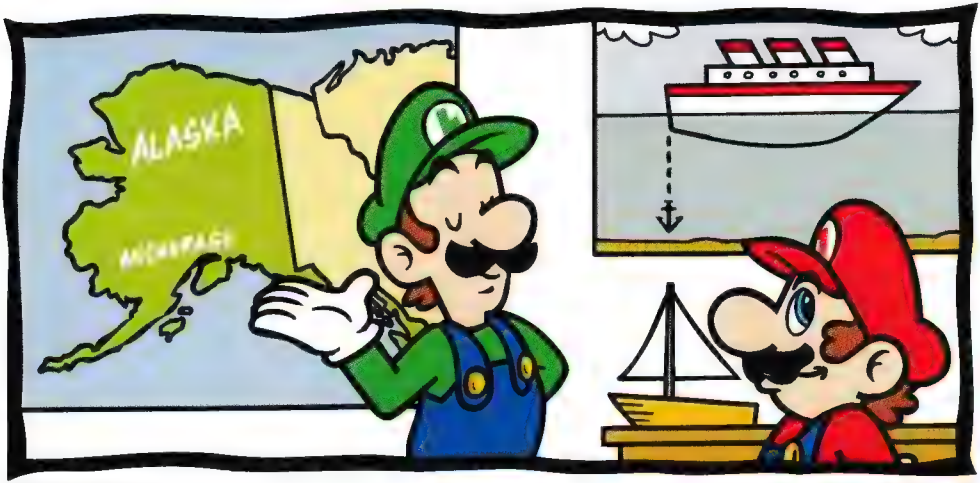

Illustration: Gary Fields

©1997 Nintendo

Anchorage

Boaters who are on extended cruises can't drop anchor for the night anyplace they feel like. They generally spend the night at an anchorage.

1 **An anchorage is a place where a boat may safely drop anchor.**

© L. Maquet

A boater chooses an anchorage for the protection it provides. A pretty view is a nice bonus.

Pleasure boaters might drop anchor several times during a day of cruising. If the group wants to stop for a swim or to have lunch in a pretty spot, the captain may drop anchor to hold the boat in one spot for an hour or so. At the end of the day, if the boat is not returning to its home marina, boaters head for an anchorage where the boat can safely spend the night.

Quiet Spot

Nautical maps direct boaters to anchorages. A boater chooses an anchorage based on the shelter it provides from wind and other hazards. Some anchorages offer better protection than others during foul weather. An anchorage also must be deep enough to accommodate the boat, and the bottom must be able to hold an anchor securely.

Once the anchorage site has been chosen, the captain drops anchor and secures it so the boat stays put for the night.

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If a boater talks about a PFD, what does he or she mean?

BY AIR AND BY SEA

1. Partially Foggy Day
2. Permanent Fixed Deck
3. Personal Flotation Device

Illustration: Gary Fields

©1997 Nintendo

PFD

The law requires that every pleasure boat carry a PFD, or personal flotation device, for each passenger on board. The most common type of PFD is a life vest.

3 To a boater, a PFD is a personal flotation device.

© E. Quemere / CEDRI

Large boats may carry inflatable life rafts for emergency use. A life raft doesn't take the place of a PFD. A bright orange life vest, like the one the man on the right is wearing, keeps a person afloat and helps a rescue crew spot him from a distance.

The U.S. Coast Guard rates life vests, or life jackets, based on their buoyancy, or how well they keep a person afloat. Boats that travel far from shore to the open sea usually carry life vests that are designed to keep a person afloat for a long time. These life vests are so buoyant, they can keep an unconscious person from drowning. They're designed to float so that the person's head remains out of the water. They even can force an unconscious person to turn from a face downward position to face up. These life vests really can save a life!

Other PFDs

In calm waters and under conditions where rescue would not be overly difficult, boaters might wear slightly less buoyant life vests. Since these vests are less bulky than the heavy duty vests, they're also worn by water skiers and other people who need freedom of movement in the water.

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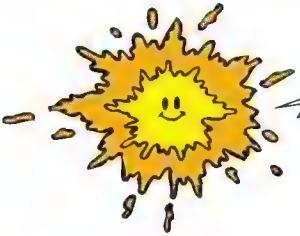
What colors are the lights on the right and left sides of a boat?

BY AIR AND BY SEA



1. Blue and yellow
2. Green and red
3. They're both white

Illustration: Gary Fields

©1997 Nintendo

Navigation Lights

Boats that are used at night must be equipped with navigation lights. They're not intended to help boaters see the water ahead of them. They're illuminated to make the boat visible to other boats.

2 Lights marking the right and left sides of a boat are green and red.

© L. Charpentier / Sea and See

The left, or port, side of a boat is marked with a red light. A boat's navigation lights must be used at night and during foul weather.

A boat's navigation lights include a white masthead light located on the mast about halfway from the top. A white stern light is located in the middle of the boat's tail end or stern. The right, or starboard, side is marked with a green light. The left, or port, side is marked with a red light.

Coming or Going

Knowing the positions of a boat's lights can help a sailor identify the type of boat he is approaching and which way it is headed. If a boat is approaching head on, the sailor sees both the port and starboard lights, as well as the masthead light. If the boat is heading away, the sailor sees the stern light. If the boat is heading left, the sailor sees only the red port light, and if it's heading right only the green light is visible. Specialized boats such as tug boats carry additional lights that make them recognizable even in the dark.

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What do boaters use to signal distress?

BY AIR AND BY SEA

1. Telegrams
2. Braille
3. Flares

Illustration: Gary Fields

©1997 Nintendo

Distress Signals

The first thing a boater in distress does is use the boat's radiotelephone to call for help. If the radio doesn't work, the boater has other ways to signal for help.

3 Flares are sometimes used as distress signals.

© J.-P. Launay / Sea and See

A signal flare may be held in the hand or launched from the deck of the boat.

There are many ways that a boater in trouble can signal to other boaters for help. The boat's radiotelephone is its main communications link to other boats in the area as well as to marinas and Coast Guard stations. The radiotelephone transmits and receives on several different channels. At least one channel is kept clear at all times for distress messages. The channel is monitored constantly by the Coast Guard. If the radio doesn't work, a boat may sound its foghorn as an alarm. One long, continuous blast of the horn will alert other boaters to come to the rescue.

Visual Signals

A boater must be able to signal distress visually. One way this is done is by shooting off signal flares. Another way is for the boater simply to stand on deck and wave his arms. A common distress signal in the U.S. is flying the U.S. flag upside down.

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What was a scuttle on an old-time naval ship?

BY AIR AND BY SEA

1. Quarters where the crew slept
2. A type of tripod used to hold a telescope
3. An opening in the hull from which a cannon protruded

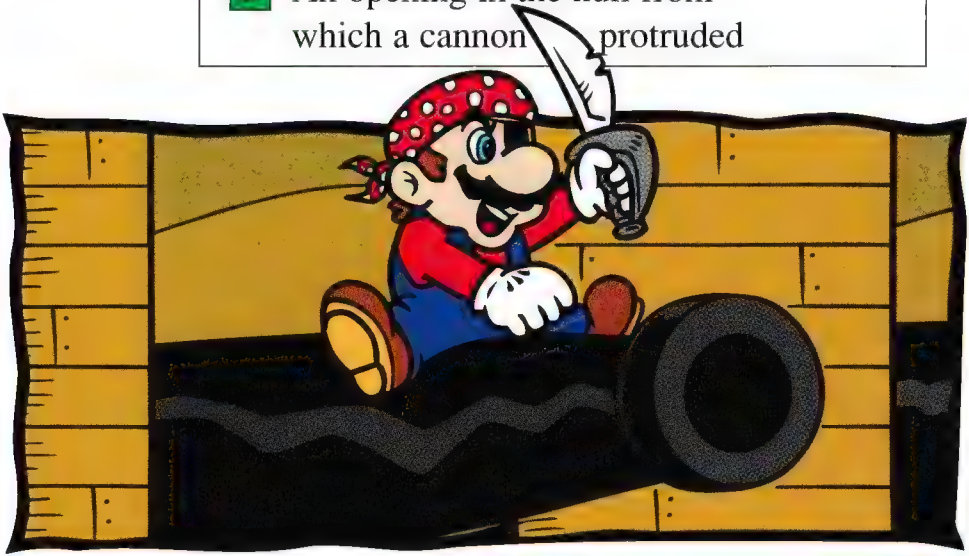

Illustration: Gary Fields

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Cannons

In naval warships from the 17th through the 19th centuries, the main weapons were cannons. Ships were equipped with two, or sometimes three, tiers of gun decks.

3 A scuttle was an opening in the hull from which a cannon protruded.

© J. L. Charmet / Explorer

The muzzles of cannons protruded from the sides of naval warships in the 18th century.

One ship might carry 100 cannons on board. They were powerful weapons, but they were heavy and hard to maneuver. A cannon's muzzle could be shifted only slightly—about a foot to either side.

Recoil

All the ship's cannons were mounted on wheeled platforms. When a cannon was fired, the force of the blast caused the body of the cannon to travel backward. This is known as recoil. To keep the cannon from rolling across the deck, each platform was anchored to the side of the boat with a heavy rope.

Each time the cannon was fired it had to be reloaded. This was done by moving the cannon away from the side of the boat so that a new cannon ball, or shot, could be placed into the muzzle. A system of thin ropes and pulleys was used to roll the cannon back and forth for loading.

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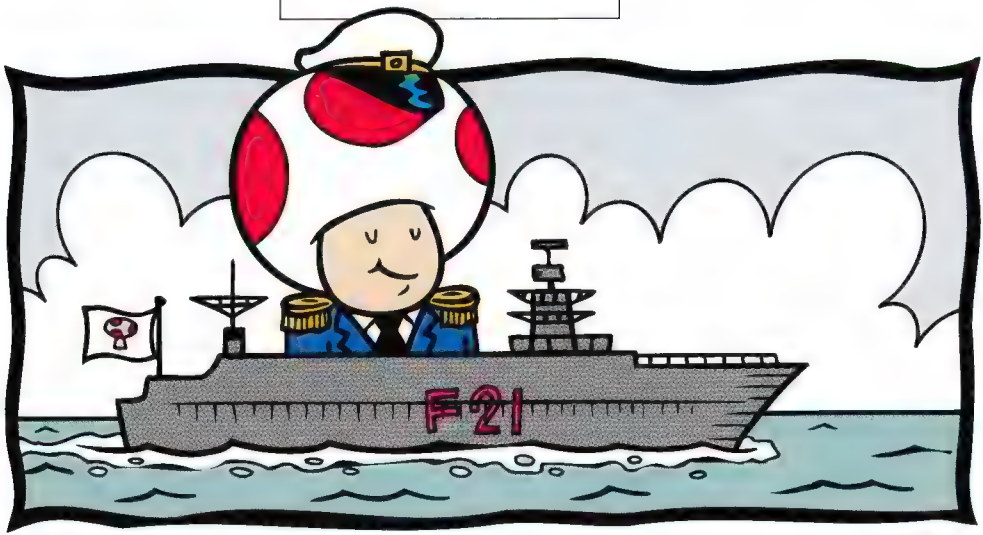
Which is a naval ship?

BY AIR AND BY SEA

1. Frigate
2. Hydrofoil
3. Trawler



Illustration, Gary Fields

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Frigate

The class of naval ship known as a frigate has existed for centuries. In a modern navy, a frigate is a small, all-purpose vessel that is commonly used to escort other ships.

1 A frigate is a naval ship.

© A. Borrel / Gamma

A modern naval frigate doesn't look like it's ancestor—a three-masted sailing ship—but it performs many of the same duties.

In the days before modern, motorized ships, naval battles were waged in wooden sailing ships that carried guns or cannons. Frigates were a class of small warships with three masts. Though they carried guns, frigates weren't used as attack ships. They were too small, and they didn't carry enough firepower to allow them to succeed in battle. Instead, frigates were used as lookouts. They were fast and could maneuver well. They traveled ahead of larger, slower warships and scouted the area for enemy vessels. Frigates also were used to escort supply ships through enemy waters.

Useful Vessel

Though modern frigates carry sophisticated weapons and surveillance equipment, their function in the navy hasn't changed much. Frigates can be used to defend against submarine or air attack, but their primary function is as armed escorts for other vessels.

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How do hang gliders stay aloft?

BY AIR AND BY SEA

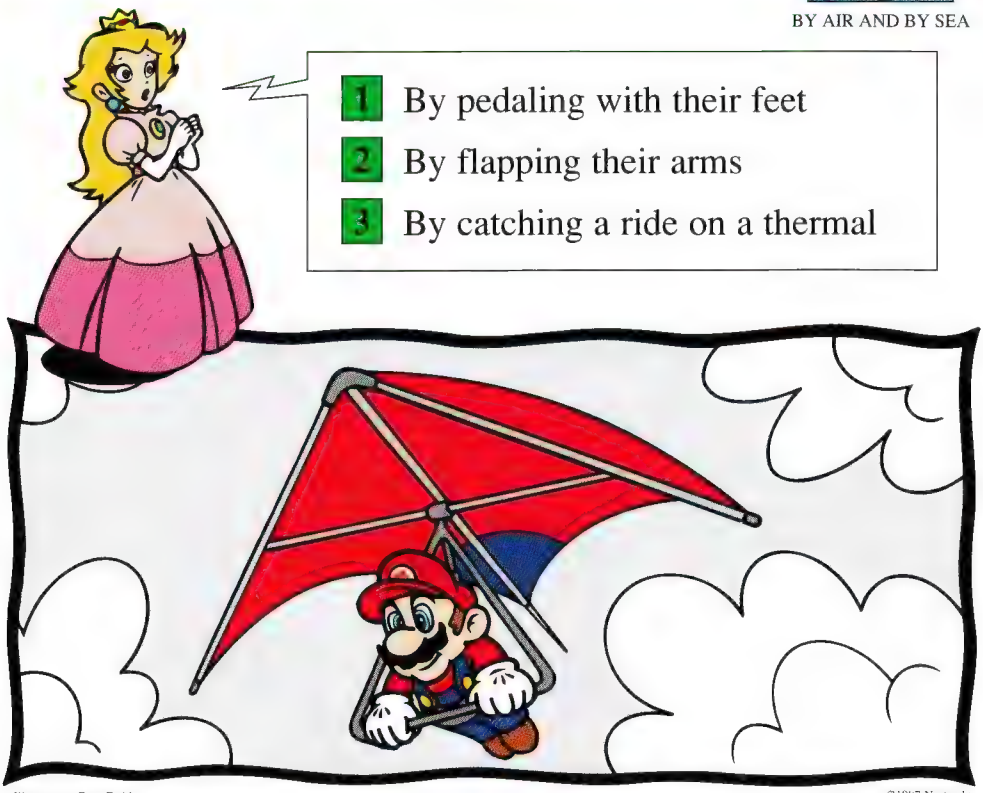

Illustration: Gary Fields

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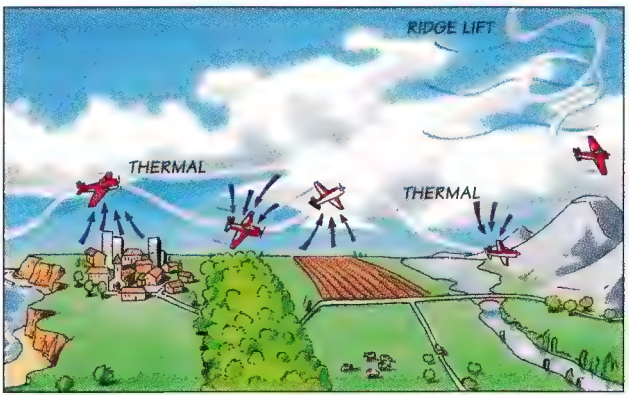
Thermals

Masses of rising warm air are called thermals. By directing their crafts toward thermals, hang gliders and glider plane pilots can stay aloft for long periods.

3 Hang gliders ride thermals to stay aloft.



© Y. Tabaré

When a glider plane passes over a city, thermals carry it upward. Cooler air over a forest lets the plane down slightly. Thermals also develop over dark areas of Earth's surface, such a plowed fields. Ridge lifts occur near mountains.

Catching a thermal can propel a hang glider up to altitudes of 10,000 feet (3,000 m) and can prolong a flight by ten minutes. Hang gliders learned how to use thermals by watching birds. Vultures, for example, gain altitude by flying into a thermal and letting the warm, rising air carry them upward.

Rising Heat

Thermals form near Earth's surface where heat is concentrated. Cities and areas with lots of pavement hold in heat and their warmth produces thermals.

Ridge Lifts

Hang gliders also use ridge lifts to stay aloft. These updrafts are caused by mountains which deflect gusts of wind and cause them to bend upward. This is another technique humans learned from birds. Birds that live in mountainous areas, such as hawks and condors, use ridge lifts to carry them upward.

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Which French luxury liner was turned into a U.S. Navy ship?

BY AIR AND BY SEA

1. The *France*
2. The *Normandie*
3. The *Queen Mary*

Illustration: Gary Fields

©1997 Nintendo

Normandie

The French steam ship *Normandie* made its first voyage in 1935. At that time, it was the largest ocean liner in the world.

2 The *Normandie* became a U.S. Navy ship.

© J.-L. Charmet / Explorer

In its day, the *Normandie* set the standard for elegance at sea. It was bigger, heavier, and faster than any ship in its class.

In the 1930s, every new ocean liner was made to be bigger, faster, and more luxurious than any ship before. The introduction of the *Normandie* set a new standard for elegance at sea. On its first crossing from France to New York, the *Normandie* easily broke the speed record for a transatlantic crossing.

Life During Wartime

The ship was only in service a few years before World War II, when Germany invaded France. At that point, it was no longer possible for French liners to cross the Atlantic. The *Normandie* stayed in New York for safety. In 1941, the U.S. government seized the ship, removed its lavish interiors, and used it for troop transport—renaming it the *Lafayette*. Sadly, a welder's torch caused the ship to catch fire in 1942. The blaze couldn't be contained, and the luxurious ship was lost forever.

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What is the current name of the *SS France*?

BY AIR AND BY SEA

1. *SS France*
2. *SS Norway*
3. *SS United States*

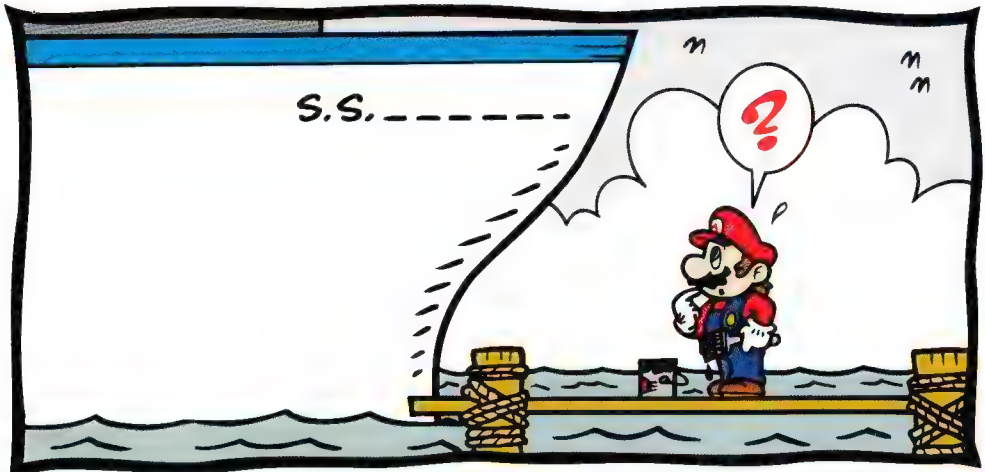

Illustration Gary Fields

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SS France

At one time the *SS France* was the "ship of state" for the country of France. It was an elegant cruise ship that sailed the North Atlantic.

2 The *SS France* is now called the *SS Norway.*

© D. Burnett / Gamma

The *SS France* traveled from the port of LeHavre in France to New York Harbor.

From the time the *France* was put into service in 1960, it was used to make crossings from LeHavre, France, to New York, usually stopping at the port of Southampton in England. The ship was known for its luxurious accommodations and outstanding food. Many people considered it the finest French restaurant on land or sea!

End of an Era

The *SS France* provided luxury transatlantic service until 1974. At that point, air travel had all but wiped out the great transatlantic cruise ships. For five years, the ship sat unused while businesspeople and the French government decided what to do with it.

In 1979, the ship was purchased by Norwegian Caribbean Lines. It underwent a major renovation and modernization, and now it's the line's flagship, rechristened the *SS Norway.*

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What caused the *Titanic* to sink?

BY AIR AND BY SEA

1. Fire on board
2. Collision with an iceberg
3. It was hit by a torpedo

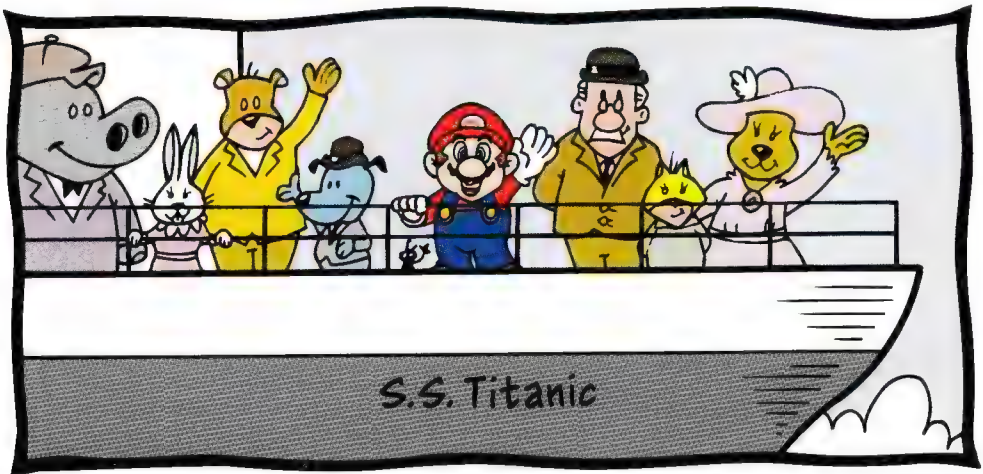

Illustration: Gary Fields

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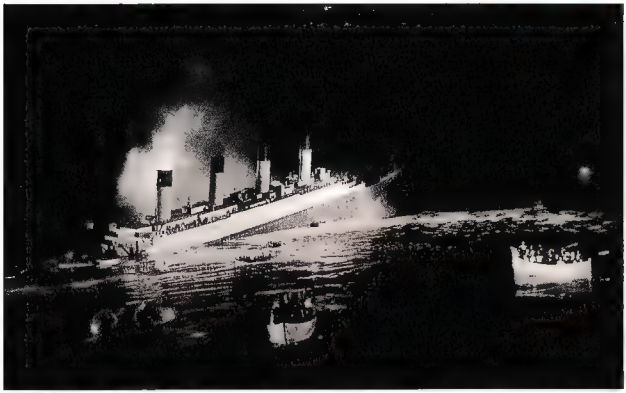
Titanic

The wreck of the *Titanic* in 1912 was one of history's worst disasters at sea. More than 1,500 people died.

2 The *Titanic* collided with an iceberg.



© Gladu / Explorer

On the night of April 15, 1912, the *Titanic* collided with an iceberg and sank. More than 1,500 people were killed.

The *Titanic* was an English ocean liner built to carry passengers across the Atlantic Ocean from England to the United States. It represented the most modern shipbuilding techniques of its time, with improved safety features such as watertight doors. Some people believed the ship was so safe that it was virtually unsinkable.

A Night to Remember

On its first voyage, in April 1912, the *Titanic* collided with an iceberg in the North Atlantic. Within 2 1/2 hours, the huge boat completely sank. Of the 2,224 passengers and crew members on board, only about 700 survived.

Divers have since found the wreckage of the ship. They've recovered a number of artifacts and personal belongings from the wreckage, and pieces of the ship's hull have been raised for study and examination.

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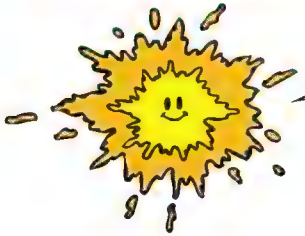
On which craft were propellers first used?

BY AIR AND BY SEA



1. Airplane
2. Helicopter
3. Submarine

Illustration: Gary Fields

©1997 Nintendo

Propeller

A propeller is a series of blades attached to a hub and controlled by an engine. The engine makes the blades turn, and their motion propels a craft forward.

3 Propellers were first used on a submarine.

© J. Sullivan / Explorer

The spinning motion of an airplane's propellers creates force that drives the plane forward.

In 1776, American colonial inventor David Bushnell built the first underwater warship or submarine. It was only big enough for one person and it was powered by a hand-cranked propeller. The person inside the craft had to continually crank the propeller to make the craft move forward. Turning a second propeller made the submarine move up and down.

Boats and Planes

Though Bushnell's submarine was not successful, the idea of the propeller caught on. Swedish-American engineer John Ericsson built a propeller for boats in the 1830s. Soon after, it replaced the large paddle wheels on steam ships.

Early aircraft propellers were made of wood and they turned slowly. They provided only enough power for a drifting airship. The Wright Brothers advanced propeller technology when they built metal propellers capable of spinning at 350 revolutions per minute.

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Where are a plane's ailerons located?

BY AIR AND BY SEA

1. In the cockpit
2. In the fuselage
3. On the wings

Illustration: Gary Fields

©1997 Nintendo

Ailerons

Certain flaps on a plane's wings are called ailerons. Changing their position causes the plane to change direction.

3 **The ailerons are located on the wings.**

© P Gleizes / Explorer

Ailerons are the primary control flaps on the wings of small planes. On the wings of jetliners, however, ailerons are part of an elaborate system of slats, flaps, and spoilers, or brakes.

As a plane flies, air passes over it, under it, and around it. By deflecting the air as it flows past the plane, a pilot can control the plane's direction and flight path, making it gain or lose altitude and bank or turn to the right or the left.

At the Controls

On a plane's wings and tail are several movable flaps which can be adjusted to deflect airflow in a particular direction. The vertical, or upright, flap on the tail is called the rudder. It's used to turn the plane left or right. Horizontal flaps on the tail are called elevators. They're used to lift or lower the plane's nose so it gains altitude or dives.

Ailerons are horizontal flaps on the wings. They're operated by a control stick, similar to a joystick, in the cockpit. Pushing the stick to the left, raises the left aileron and lowers the right. This makes the plane bank to the right.

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What is a dock?

BY AIR AND BY SEA

1. Sleeping quarters on a ship
2. Space where cargo is stored on a plane
3. An area of water next to a pier

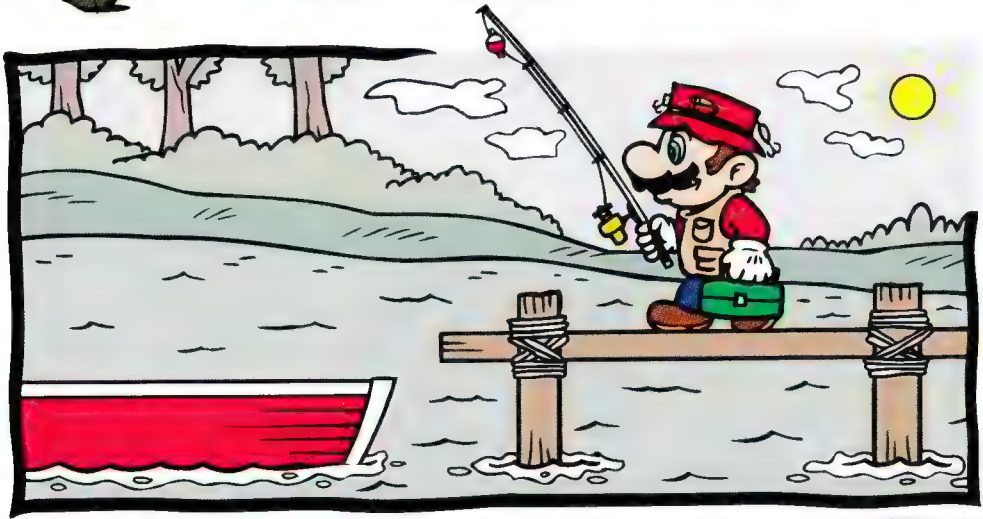

Illustration: Gary Fields

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Dock

A dock is like a parking space for a ship. Ships stop at docks for loading, unloading, and repairs.

3 A dock is an area of water next to a pier.

© D. Prix / Sunset

The heavy machinery on the piers beside some docks includes cranes for lifting cargo containers onto and off of ships.

On one or both sides of a dock are platforms called piers. They give access to the ship.

Dry Dock

When a ship needs repairs or cleaning on its underside, or hull, it's moved into dry dock. A dry dock is an enclosed basin that can be sealed to prevent water from entering. On the floor of the dry dock is a raised platform to hold the ship in place when the water is removed.

Repair Work

First, the dry dock basin is sealed with a movable gate. Then it's flooded until the water level inside the basin is the same as the water level of the sea around it. The gate is lifted and the ship is maneuvered into the dry dock. Then the gate is closed and the water is pumped out.

The ship rests on the platform while repairs are made. When the ship is ready for service again, the dry dock is flooded and the ship floats back out to sea.

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When was the world's first nuclear submarine launched?

BY AIR AND BY SEA

1. 1954
2. 1969
3. 1989

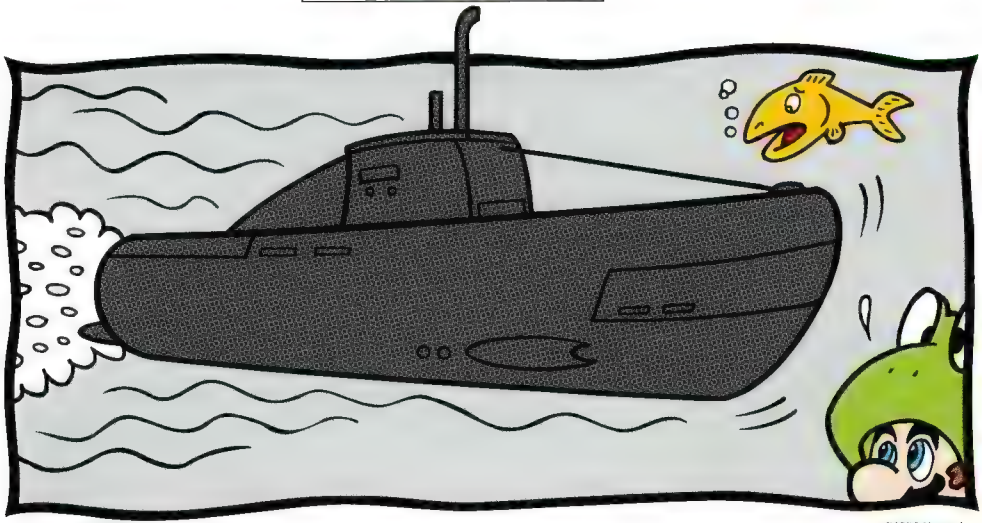

Illustration: Gary Fields

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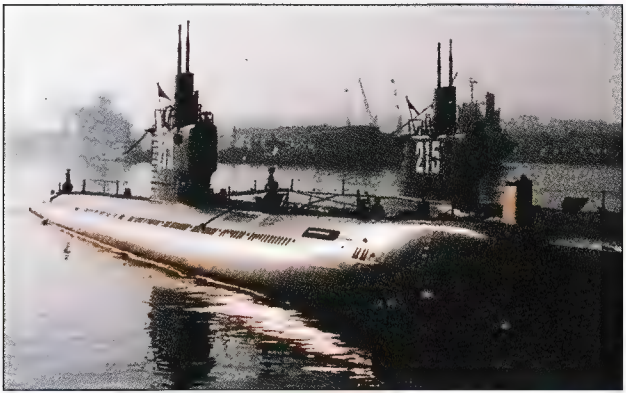
Nuclear Submarines

The *USS Nautilus,* built in Groton, Connecticut, was the world's first nuclear powered submarine.

1 **The the first nuclear submarine was launched in 1954.**



© Len Sirman

The *USS Nautilus* was taken out of service in 1980. Now it's on display at a submarine museum in New London, Connecticut.

Nuclear subs are powered by an onboard nuclear reactor that produces steam to drive turbines that propel the craft forward. Without the need to resurface or refuel, nuclear subs can remain submerged, traveling at top speeds almost indefinitely.

Long Distance Travel

To demonstrate its capability, the *Nautilus* traveled under the polar ice cap at the North Pole in 1958. In 1960, its sister sub, *Triton,* traveled around the world without surfacing.

Historic Name

The nuclear sub was not the first to be named *Nautilus.* Robert Fulton, known for his work with steam ships, built a sub in 1800 which he named *Nautilus.* In 1886, an electric-powered sub had the same name. But the most famous *Nautilus* was the fictional sub in author Jules Verne's novel *20,000 Leagues Under the Sea.*

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What makes a biplane unique?

BY AIR AND BY SEA

1. It can fly forward or backward
2. It has two sets of wings
3. It has two cockpits

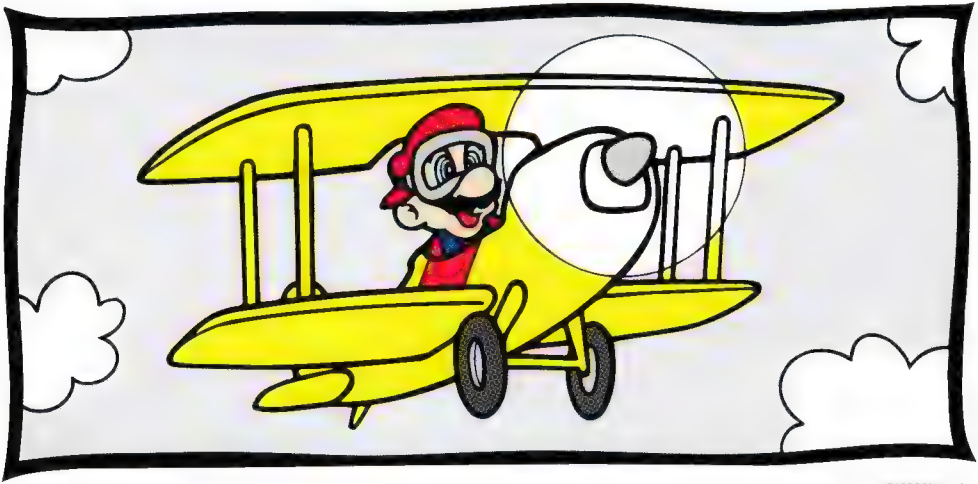

Illustration Gary Fields

©1997 Nintendo

Biplane

Wilbur and Orville Wright's first powered flight, in 1903, was in a biplane. The craft had two sets of wings, both made from cotton fabric stretched over wood and metal framework.

2 A biplane has two sets of wings.

© Moulu / Sunset

A biplane has two wings stacked one on top of the other. Most modern aircraft are monoplanes, with a single wing.

The biplane design was introduced in gliders in the 1890s. The Wrights chose a biplane design for their aircraft because biplanes are stable and comparatively easy to maneuver.

Form and Function

Biplanes were the predominant aircraft during World War I and into the 1930s. Aircraft engineers even introduced a triplane—three wings stacked one of top of the other—during World War I.

By the 1930s, however, aircraft designers were most interested in building faster planes. Though biplanes offer pilots control that makes them great for stunt flying, they're heavy and relatively slow. So, during World War II, the military biplane was replaced by a single-wing "monoplane" which was lighter and could fly at higher speeds.

Since World War II, biplanes have been used mainly for aerial acrobatics and stunt flying.

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When were jet engines first used on airplanes?

BY AIR AND BY SEA

1. 1940s
2. 1950s
3. 1960s

Illustration: Gary Fields

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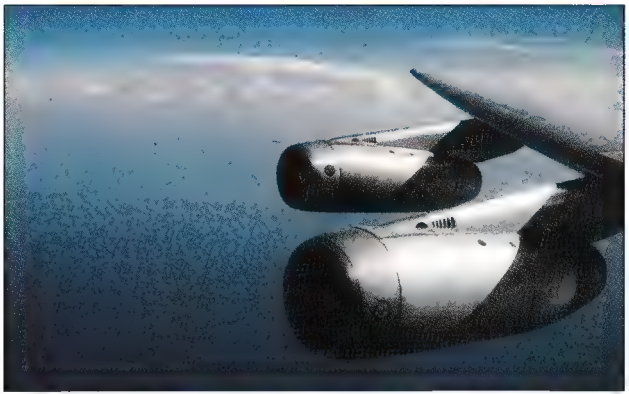
Jets

The first planes equipped with jet engines were military aircraft flown in World War II.

1 Jet engines were first used on airplanes in the 1940s.



© F. Lochon / Gamma

Jet engines were first used on military aircraft in the 1940s. They weren't used for commercial, or passenger, aircraft until the 1950s.

Jets are faster and quieter than the propeller planes they replaced. Though English engineer Frank Whittle designed the first jet engine in 1928, he didn't build a prototype engine until 1937. The first plane to carry a jet engine was built by German engineer Ernst Heinkel in 1939—just in time for World War II.

Oxygen Boost

Air enters a jet engine through a duct in the front. Once inside, it mixes with jet fuel and is ignited. As the fuel burns, it releases gases that need to escape from the combustion chamber inside the engine. The gases escape from the rear of the engine, and the force they create as they leave propels the plane forward.

Airplane jet engines work by using the oxygen in the air. Rocket engines, which are a modified form of jets, carry their own oxygen. This allows them to work beyond Earth's atmosphere and in the low-oxygen regions of outer space.

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What is the usual minimum age for flight attendants?

BY AIR AND BY SEA

1. 18
2. 21
3. 30

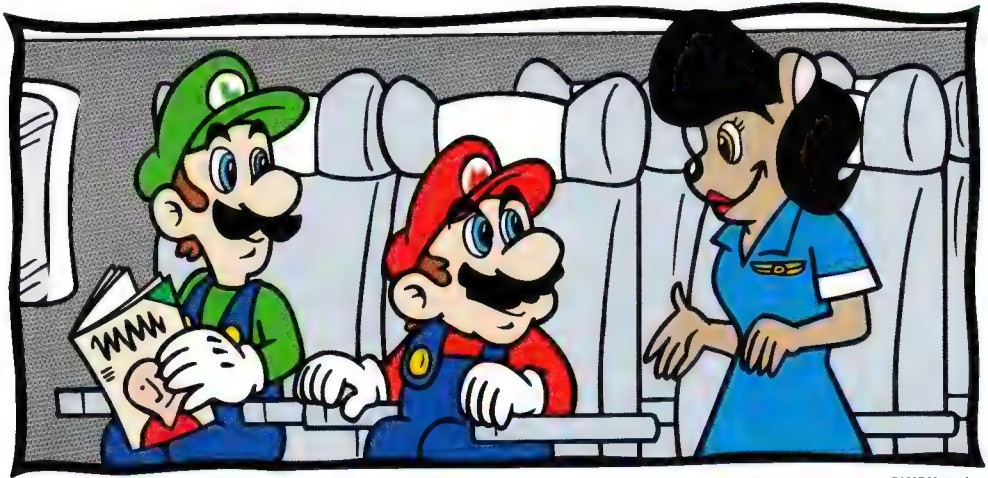

Illustration: Gary Fields

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Flight Attendants

A flight attendant's job is to keep airline passengers comfortable and safe. Both women and men may train to be flight attendants.

2 Most airlines require flight attendants to be at least 21 years old.

© ISEPL / Jerrican

Much of a flight attendant's time is devoted to serving meals and beverages, and to keeping passengers comfortable in-flight. A flight attendant must also be quick-thinking and calm in an emergency. Those who fly international routes must speak more than one language, too.

Most airlines have physical requirements for flight attendant candidates. These generally include a minimum and maximum height requirement. Flight attendants must be in top physical condition and they must have perfect, or near-perfect, vision.

Training School

People who are selected to become flight attendants must attend training programs before they are assigned to work. At these training programs, which usually last several weeks, candidates learn first aid and emergency safety procedures. They also learn their way around an airplane cabin and galley, or kitchen area. They practice emergency drills and they learn how to serve meals efficiently, quickly, and safely in flight. After training, new flight attendants are assigned to regular flight routes. They may travel throughout the United States or around the world.

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Are all aircraft detectable by radar?

BY AIR AND BY SEA

1 Yes

2 No

Illustration: Gary Fields

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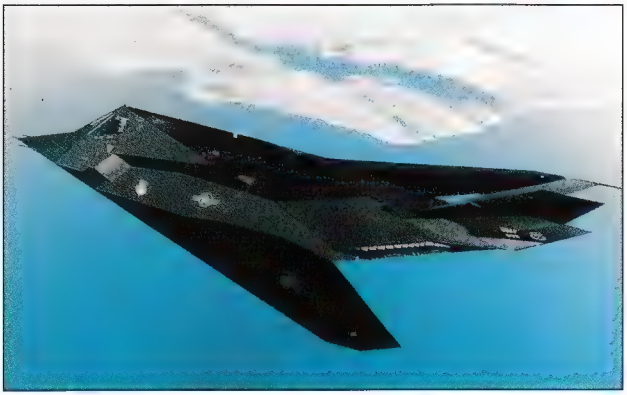
Stealth

Ever since radar detection was invented, in the 1930s, engineers have been trying to design aircraft that could beat it!

Radar stands for radio detection and ranging. Though it has many commercial uses today, it was created as a military tool that armies used to identify and track enemy aircraft.

A radar system releases radio waves into the air. They travel until they meet a solid object—such as an aircraft. Then the waves bounce off the object and return to their source. The time it takes for the waves to return indicates the position of the object.

2 No, some aircraft cannot be detected on ordinary radar.



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The Lockheed F-117A Stealth Fighter and the Northrop B-2 Stealth Bomber are made from plastic materials, with rounded surfaces and cool engines which can't be detected by ordinary radar.

Invisible Aircraft

Radar works because virtually all aircraft are constructed of materials that reflect the radio waves. So, engineers set out to design a plane that could absorb the waves instead of reflecting them. If the plane didn't reflect the waves, it would be invisible to radar!

Stealth aircraft, introduced in the 1980s, were the first to successfully avoid radar detection and still function effectively.

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Can satellites help boats navigate?

BY AIR AND BY SEA

1 Yes

2 No

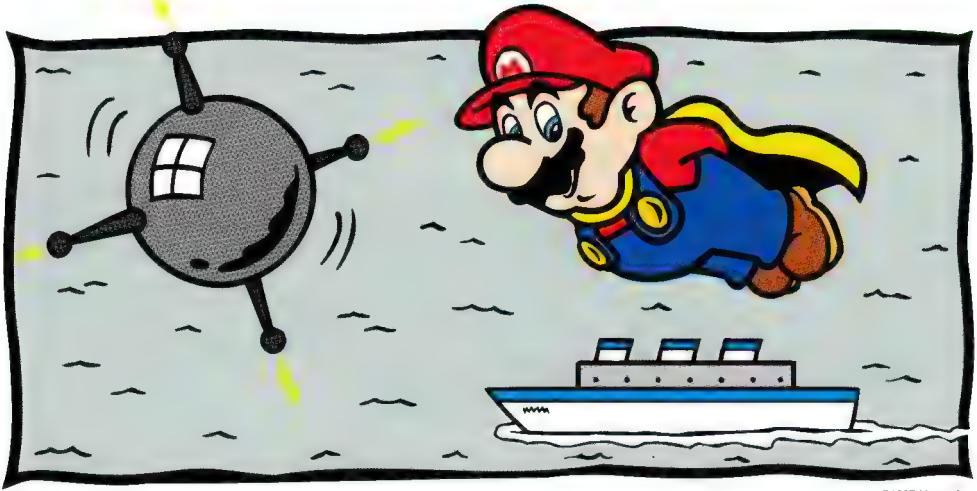

Illustration Gary Fields

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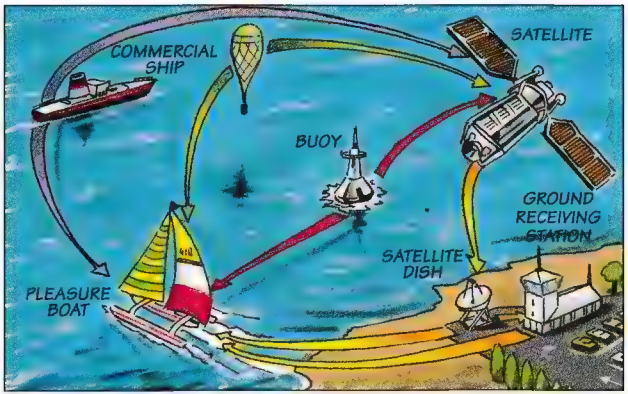
Navigation

Satellites in the Global Positioning System, or GPS, help boats and other vehicles navigate. GPS was originally only for military craft. Now it's used by commercial boats and planes.

1 Yes, satellites are used to help boats navigate.



Global Positioning System satellites send distinctive signals to ground-based receiving stations and buoys. The signals are used by boats and planes to determine their positions.

There are 24 GPS satellites orbiting 11,000 miles (17,600 km) above Earth. Each satellite emits a distinctive signal that can be picked up by receivers on Earth.

Pinpointing Position

Boats and planes carry GPS receivers. When a receiver picks up the satellite signals—usually four or five at one time—it can determine its position based on the position of the satellites. Since boats and planes often have no landmarks to guide them, this navigation system is extremely valuable.

Accurate Assessment

GPS recently became even more accurate with addition of fixed ground receiving stations. The ground stations receive the satellite signal and retransmit it. When planes and boats receive the signal from the ground stations, they can determine their position within 21 feet (7 m).

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What are beacons used for?

BY AIR AND BY SEA

1. Communications
2. Emergency safety
3. Guidance

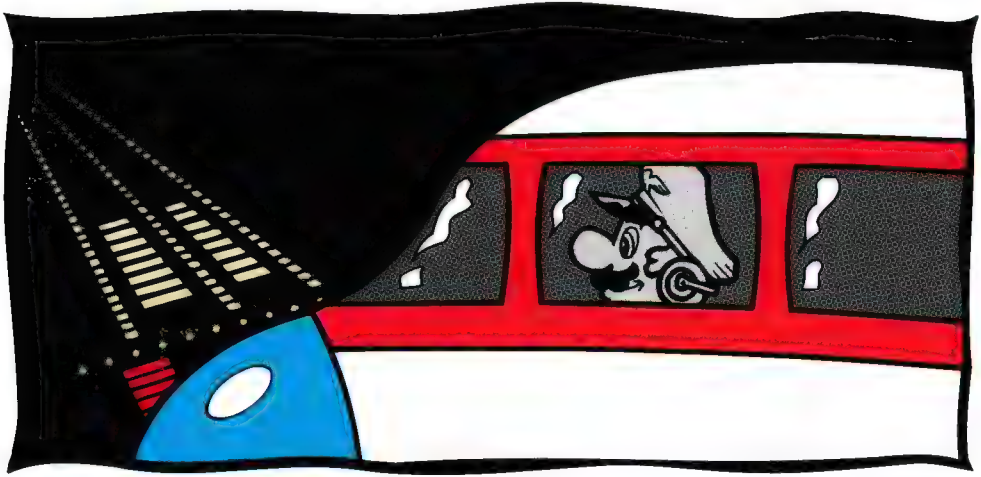

Illustration Gary Fields

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Beacons

Beacons are used to manage air traffic at airports. They guide planes with light, radar beams, or radio waves.

3 Beacons are used for guidance.

© ISEPL / Jernvan

Beacons mark runways so planes can find them at night and in foul weather.

A beacon is a signaling device used for navigational guidance. Beacons at airports mark the position of the runways so planes can find their way to the appropriate landing strip even in darkness or foul weather. Light beacons mounted on tall buildings or structures warn low-flying planes of obstacles and hazards.

Point of Reference

Airports have beacons evenly spaced around the landing area. Incoming aircraft fly directly over a beacon to find a landing strip. Planes take off on a diagonal course between two beacons. With this system, incoming and outgoing planes do not use the same runway at the same time.

Planes in flight use beacons to determine their location. Since the beacons are in fixed positions on the ground, when a plane receives a signal from a beacon the pilot can tell where the plane is in relation to the beacon.

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How do research submarines differ from military subs?

BY AIR AND BY SEA

1. Research subs are faster
2. Research subs can stay underwater longer
3. Research subs are smaller

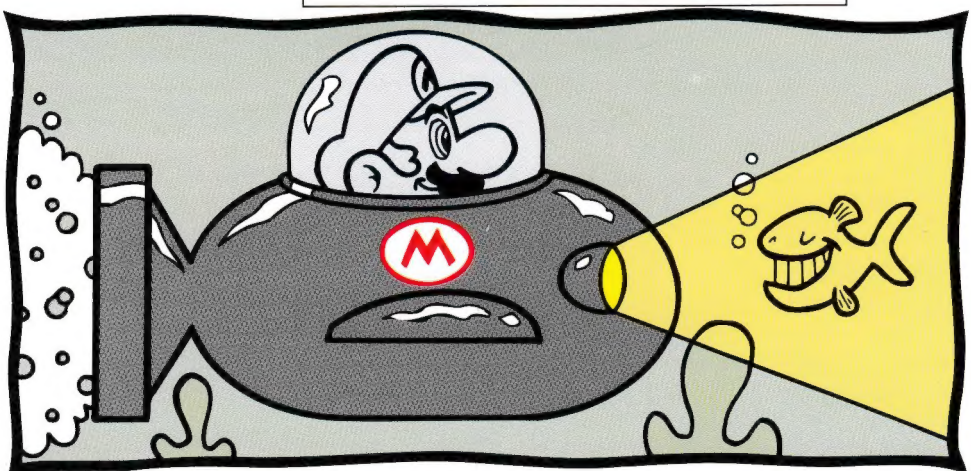

Illustration: Gary Fields

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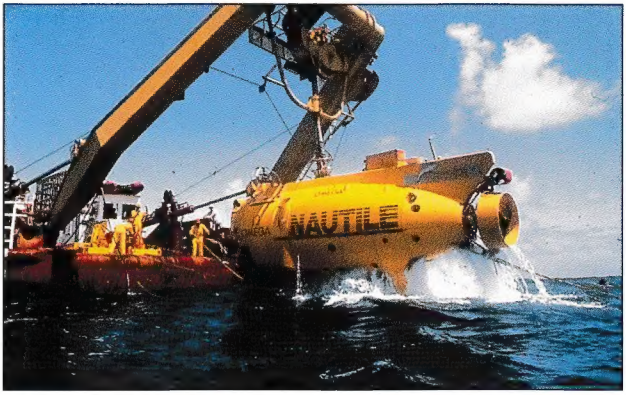
Research Submarines

Most research subs work in tandem with a research ship on the surface. The ship helps the sub dive and surface.

3 Research subs are smaller and lighter than military subs.



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The submersible *Nautile,* shown here, was used to explore the wreck of the passenger ship *Titanic.* The *Nautile* works in tandem with the ship *Nadir.* It holds a crew of three people and dives to a depth of 19,800 feet (6,000 m).

Research subs, known as submersibles, conduct experiments, make observations, and take samples from the ocean floor. They have also been used for unusual missions, such as photographing the wreckage of the *Titanic.*

ALVIN and Friends

The main research sub at the Woods Hole Oceanographic Institute in Massachusetts, is known as ALVIN. When it was built in the 1960s, it was named in honor of the Institute's director, Allyn Vine (and cartoon character Alvin the Chipmunk!).

In its history, ALVIN has had a variety of missions. In 1966, it helped recover an unexploded hydrogen bomb dropped accidentally off the coast of Spain. In 1986, it was part of a joint effort between the United States and France to photograph the wreckage of the luxury liner *Titanic.* The French submersible *Nautile* was also part of the expedition.

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What is drag on an aircraft?

BY AIR AND BY SEA

1. Air resistance
2. Weight of the aircraft
3. Length of the aircraft

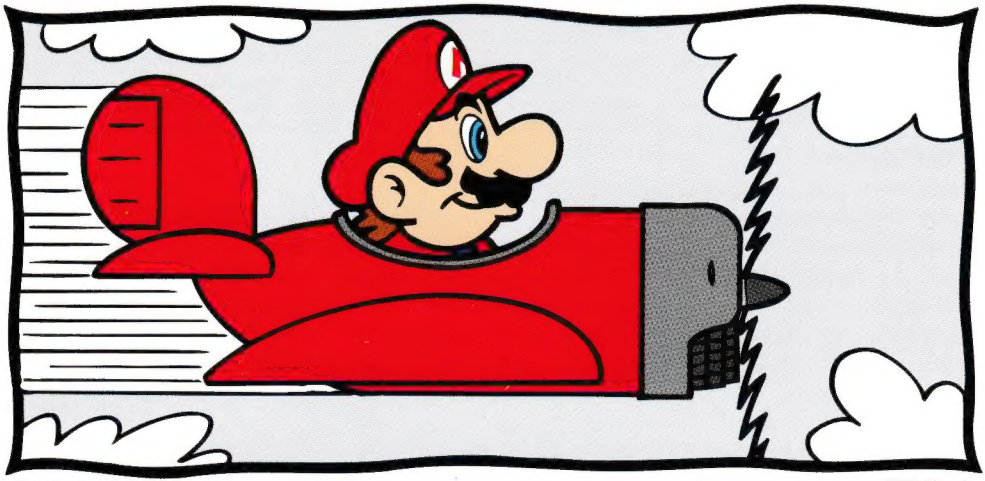

Illustration: Gary Fields

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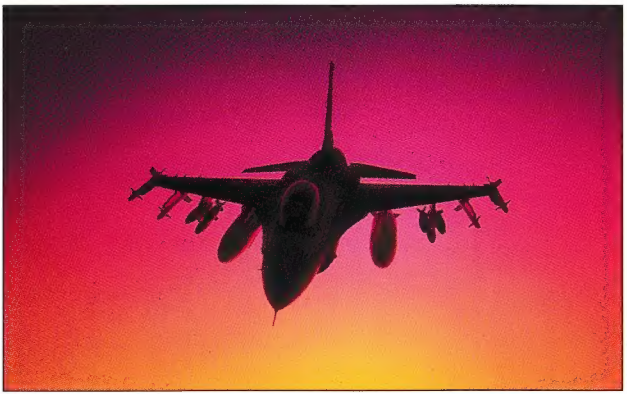
Drag

The backward force created by friction as a plane moves through the air is known as drag.

1 Drag is air resistance.



© Len Sirman

High speed military planes, like this one, often have pointed, swept back wings to reduce drag. The wings may be adjustable so that they extend for takeoff and landing, but sweep back as the plane gains speed.

A similar force affects swimmers and boats in the water. When you swim or wade through water you have to fight the resistance of the water.

What a Drag

Airplanes are equipped with high-powered engines to propel them through the air. Ironically, however, the faster a plane travels the more air resistance it meets. So, merely increasing the power of the engine isn't enough to make a plane travel faster.

Lean, Mean Machine

Planes must also be streamlined to reduce wind resistance. The plane's body is tapered, without a lot of protrusions to catch and hold oncoming air. This is why planes have pointed noses. In addition, the plane's surface, or skin, is as smooth as possible. This keeps the air flowing past the plane without creating additional drag.

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